STATE OF NEW YORK

DEPARTMENT OF CONSERVATION

WATER POWER AND CONTROL COMMISSION

THE GROUND-WATER RESOURCES OF SENECA COUNTY, NEW YORK

By

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Prepared by the

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THE GROUND-WATER RESOURCES OF SENECA COUNTY, NEW YORK

By ANDREW J. MOZOLA

ABSTRACT

This report is part of a State-wide survey of the ground-water resources in New York State which is being made by the United States Geological Survey in cooperation with the New York Water Power and Control Commission. Well and spring records were collected in 1947 and the geology was studied during the summer and fall of 1948. Approximately 540 well and spring records were obtained. Forty-two water samples also were collected for chemical analysis.

Seneca County is in the heart of the Finger Lakes region of central New York. The County has an area of 336 square miles and the 1950 census showed a population of 29,211. The principal east-west lines of transportation cross the northern part of Seneca County but an excellent system of roads makes nearly every part of the area easily accessible. Agriculture and light industry are the principal occupations in the County.

There are at least four distinct hydrologic units within Seneca County. The first and oldest of these is the Camillus shale member of the Salina formation. Yields from this member are relatively high, but the water is very hard. The mineral content generally increases with the depth of the well.

The second hydrologic unit is composed of a series of limestone beginning with the Bertie limestone member, the uppermost member of the Salina formation, and succeeded by the Cobleskill dolomite, Rondout limestone, Manlius limestone, and Onondaga limestone. The thickness of this unit is approximately 135 feet. Where the limestones are directly overlain by glacial deposits, yields of as much as 200 gallons per minute have been reported. The yield from the limestones is appreciably less where they are overlain by shales. Generally, the water in the limestones is hard.

The third hydrologic unit consists of a thick shale sequence which contains beds of limestone and is of Middle and Upper Devonian age. Yields from wells tapping the series of shales have ranged from a fraction of a gallon to 60 gallons per minute. The water is fairly hard.

The youngest of the hydrologic units is the most widespread and is composed of unconsolidated beds of Pleistocene glacial drift and Recent deposits, which mantle the older rocks. In general, the surficial cover is thickest in the northern third of Seneca County and consists of beds of outwash sand and gravel, glacial lake clay and silt, and till. The remainder of the County is covered by a thinner mantle of till. Water obtained from these unconsolidated deposits is hard.

The principal source of ground water in Seneca County is the precipitation upon the area. A secondary source is the subterranean percolation from the area north of Seneca County. The northern part of the County is in an area more conducive to the recharge of ground water than the remainder of the County.

Ground water is recovered principally by means of wells drilled into bedrock. The majority of the wells ending in bedrock are in that part of the County south of the glacial lake plain, whereas most of the wells ending in drift (mainly dug wells) are in the area lying north of the Seneca River. Approximately 95 percent of the wells are used for domestic or farm supply and the average daily pumpage of water is around 500 gallons. About 5 percent of the wells in the County are used for commercial, industrial, or municipal purposes. Seneca Falls and Waterloo, the two largest communities in the County, are in the region most favorable for the development of a ground-water supply. Both villages utilize surface water in their municipal supplies, however, because the hardness of the ground water is objectionable to the industrial and commercial establishments operating within the villages. The villages of Ovid and Interlaken, both of which are without substantial industrial establishments utilize ground water in their public water supplies. Ovid obtains its supply from two shallow gravel-packed wells, and Interlaken is served by a developed seepage-spring area. The combined consumption of the two villages is approximately 60,000 gallons per day.

On the basis of available well records it is estimated that a minimum of 3.5 million gallons of ground water is recovered daily in Seneca County. Additional supplies are available in both the consolidated rocks and the unconsolidated deposits.

INTRODUCTION

PURPOSE AND SCOPE OF INVESTIGATION

The United States Geological Survey in cooperation with the New York Water Power and Control Commission began an investigation of the ground-water resources of the State of New York in April 1945. The investigation is sponsored also by the New York State Department of Commerce, the New York State Department of Health, the New York State Science Service and the New York State Department of Public Works. The aims of the investigation are twofold: first, a systematic areal reconnaissance of the State to locate sources of ground-water supply and to appraise the quantity and quality of these supplies; second, the accumulation of data pertinent to the conservation of the ground-water resources of the State. The areas in which ground-water studies have been completed and in which work is now in progress are shown in figure 1. Reports that have been published are listed in table 8.

METHODS OF INVESTIGATION

Material for the ground-water study of Seneca County was gathered as the result of geologic field studies by the writer during the summer of 1948, and from well records and water analyses gathered by Harry D. Wilson of the U. S. Geological Survey in 1947. Additional water samples for chemical analysis were collected during the fall of 1948. The investigation was under the general supervision of M. L. Brashears, Jr., District Geologist in charge of the ground-water investigations of the Geological Survey in New York and New England.

Approximately 540 well records were collected for Seneca County, 307 of which have been compiled in table 7. Selection of the wells for tabulation was based principally upon the completeness of data pertaining to depth of well, depth to bedrock, water level, and yield. Logs of the wells were unavailable in many instances, and information was supplemented from memory by well drillers and owners of property. A few of the larger and older drilling firms and some of the individual drillers who have recognized the importance of keeping records were able to furnish valuable logs. It is highly desirable for all drillers to maintain records of wells constructed, as such records utilmately will be of benefit to the people of the State of New York and, in addition, will materially aid the members of the drilling profession.

The wells are numbered consecutively beginning with number 1; the numbers are preceded by the letters "Se" to designate Seneca County. Springs are numbered in a separate series beginning with number Se 1Sp. As an aid in reporting a well or spring location anywhere in New York State, meridian lines at 15-minute intervals have been lettered consecutively from west to east, beginning with "A" and ending with "Z". Similarly, parallels of latitude have been numbered at 15-minute intervals from north to south, beginning with "1" and ending with "17". The coordinate letters and numbers are shown on the well location map (plate 1). The intersections of the coordinates form points from which, by means of distance and direction, the wells and springs can be accurately located. For example, well Se 98 (9M, 2.5S, 0.5E) can be found 2.5 miles south and 0.5 mile east of the intersection of coordinates "9" and "M". The coordinates, distances, and directions for each well and spring are shown in the tables of well and spring records.

ACKNOWLEDGMENTS

The writer wishes to express his appreciation to the many agencies and individuals who have so generously contributed information to make this report possible. The offices of the New York State Geologist and the New York State Science Service have contributed publications and other pertinent data, and the New York State Department of Public Works at Syracuse furnished records of test borings at Montezuma Marsh and data on the bedrock along the barge canal between Seneca and Cayuga Lakes. The New York State Department of Health furnished data relating to public-water supplies and analyzed samples of water. Acknowledgment is also made of the assistance of members of the New York State Department of Commerce and the New York State Water Power and Control Commission. Credit is due the many owners of private property, well drillers, and public and private officials who have furnished information included in this report.

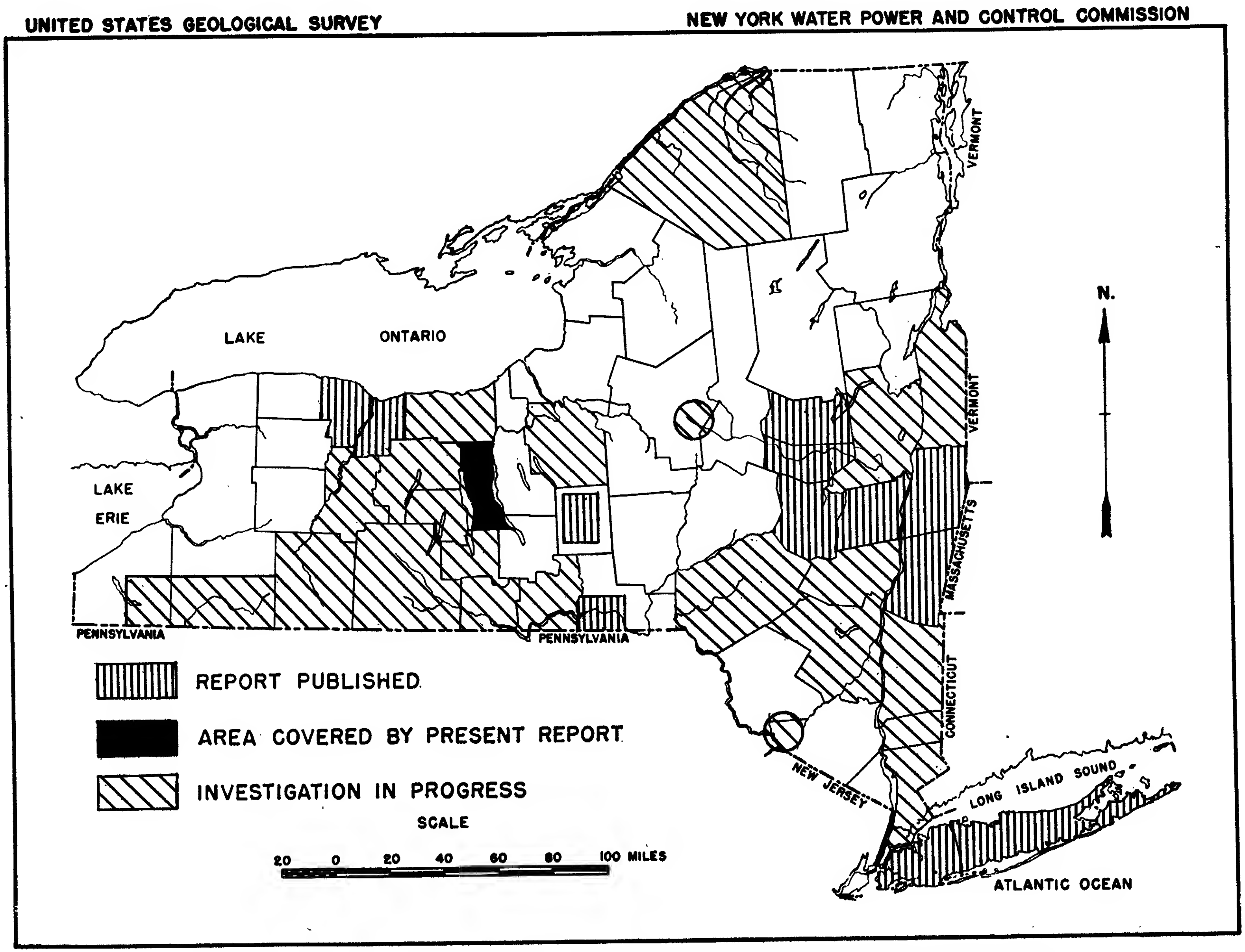

Figure 1.—Index map of New York State showing areas of cooperative ground-water studies.

GEOGRAPHY

LOCATION AND EXTENT OF THE AREA

Seneca County is in the heart of the Finger Lakes region, near the geographical center of New York State. It is bordered on the north by Wayne County, on the west by Geneva and Yates Counties, on the south by Schuyler and Tompkins Counties, and on the east by Cayuga County. The original county seat was Ovid, but, owing to the length of the County, the village of Waterloo has been designated as an alternate county seat to serve the needs of the populace in the northern part. Each village maintains a county building and courthouse.

Seneca County is roughly rectangular in shape, extending 33 miles north and south and 10 miles east and west. It has an area of approximately 330 square miles, or 211,200 acres. Seneca Lake extends along most of the western side of the County and Cayuga Lake extends along most of the eastern side.

The New York State Department of Commerce (1946)[1] includes Seneca County within the Rochester business area, together with the counties of Monroe, Ontario, Wayne, Genesee, Yates, Wyoming, Orleans and Livingston. Seneca County is in the southeastern part of the area and thus is influenced somewhat by the Syracuse and Elmira business areas.

POPULATION

In 1789 Europeans settled along the rapids of the Seneca River, which furnished water power for their sawmills and gristmills. The population has grown steadily and in 1950 was 29,211. Most of the present inhabitants are descendants of the original settlers, the majority of whom were German. Roughly, 41 percent of the people live in the villages of Seneca Falls and Waterloo, the population of which in 1940 was 6,452 and 4,010, respectively. About 30 percent of the total county populace are employed in manufacturing industries, 22 percent in agriculture, 17 percent in retail trades and service industries.

TOPOGRAPHY AND DRAINAGE

According to Fenneman (1930, p. 305), that portion of the County south of the Chemung Escarpment is in the southern New York section of the Appalachian Plateau province of eastern United States. North of Lodi and extending northward to the boundary, the County is part of the Erie-Ontario-Mohawk Plain. Figure 2 is a physiographic map of Seneca County. The present depth of the valleys containing Cayuga and Seneca Lakes is the result of glacial erosion in Pleistocene time. The broad divide or ridge separating Cayuga and Seneca Lakes is slightly above lake level at the northern terminus and rises southward in a series of rock terraces until it reaches an altitude of 1,600 feet above sea level at the southern end of the County. The slope of the land toward the lakes is steep, ranging from about 500 feet per mile in the southern part of the County to about 100 feet per mile in the northern part. Along these steep slopes many streams have cut deep gorges in the bedrock beneath the thin mantle of glacial drift.

In general, that part of Seneca County south of Fayette is well drained by numerous streams that discharge into Cayuga and Seneca Lakes. Many of the streams, particularly in their headwater areas, become dry during the summer months. The region between Fayette and the New York State Barge Canal is somewhat less well drained by the streams flowing northward to the Seneca River. The area north of the Barge Canal is drained chiefly by northward-flowing streams that empty into the Clyde River. The Finger Lakes are drained by the Seneca and Oswego Rivers, which flow through the broad, shallow depression extending eastward from Ontario County to Onondaga County.

CLIMATE

According to meteorological records collected by the U. S. Weather Bureau, the climate of Seneca County may be classified as humid continental. The dominantly continental climate is slightly modified by the Finger Lakes, whose principal influence is in the extension of the growing season. The average length of the growing season is 154 days, the mean dates of the last and first killing frosts being May 8 and October 9, respectively. The mean annual precipitation of Seneca County as observed at four stations for different periods of record is 33.39 inches and

[1] References are listed alphabetically at the end of this report.

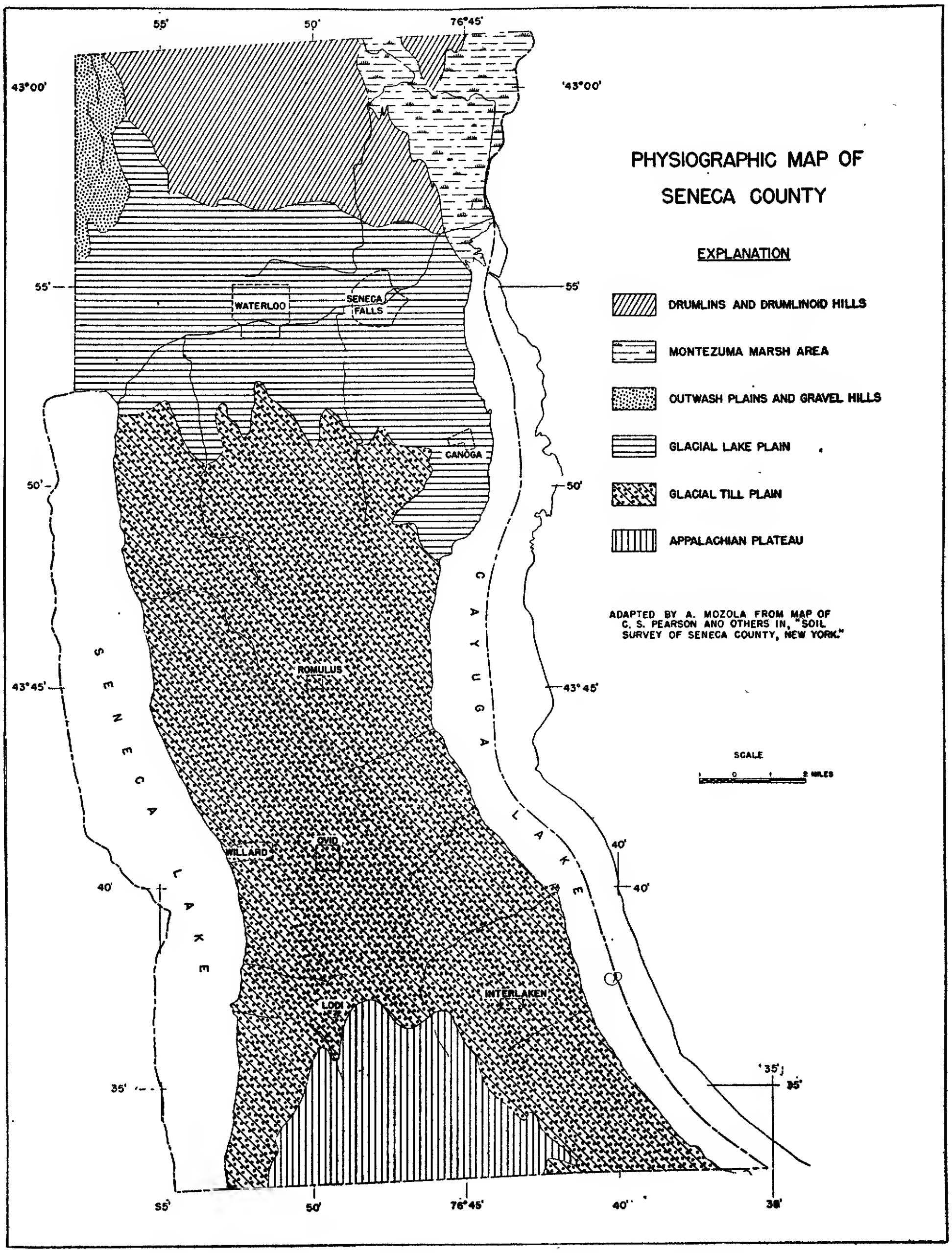

Figure 2.—Physiographic map of Seneca County, N. Y.

ranges from a low of 30.97 inches at Romulus to a high of 35.28 inches at Ovid (table 1). The annual precipitation has ranged from 22.22 inches (at Romulus) to 46.70 inches at (Mays Point). Approximately 30 percent of the total annual precipitation occurs during the summer months (June through August).

Table 1.—Precipitation data for Seneca County, N. Y.[a]

STATION	MAYS POINT (altitude 396 feet above sea level)	WATERLOO (altitude 460 feet above sea level)	ROMULUS (altitude 719 feet above sea level)	OVID (altitude 960 feet above sea level)
Period of record	1918-1947	1923-1947	1890-1922	1932-1947
Length of record (years)	27-29	24-25	27-32	15-16
Mean annual precipitation (inches)	33.78	33.53	30.97	35.28
Highest annual precipitation (inches)	46.70 (1945)	41.66 (1945)	43.20 (1902)	44.95 (1935)
Lowest annual precipitation (inches)	23.05 (1934)	23.62 (1932)	22.22 (1909)	26.04 (1934)
Highest mean monthly precipitation (inches)	3.58	3.56	3.34	4.08
Lowest mean monthly precipitation (inches)	1.95	2.09	1.82	2.14
Seasonal distribution (percent) Summer	28.2	27.7	30.2	30.2
Fall	26.6	26.2	24.2	23.5
Winter	18.9	19.0	19.1	19.7
Spring	26.3	27.1	26.5	26.6

[a] From Climatic summary of the United States; Section 80, Central New York: U. S. Weather Bur., 1935.

Temperature data for Seneca County have been recorded only at the station at Romulus, and there for a relatively short period. They indicate (table 2) that the mean annual temperature is 47.8° F. The maximum temperature recorded was 98° F. and the minimum −19° F.

AGRICULTURE

The principal agricultural activities of Seneca County are truck gardening, fruit and vegetable raising, and dairying (Pearson, 1942). The areas of good soil permit a wide diversification of farming activities. The poorer soils, which in general are heavy-textured and imperfectly drained, are best suited for the production of red clover and timothy. These areas, therefore, become centers of dairying. Although steadily increasing since 1900, dairying always has been subordinate to the production of grains, fruits, and vegetables, from which greater profits are obtained.

On the basis of acreage planted, hay is the most important crop. Wheat is second in acreage but first in cash value. Rye is grown mainly as a cover crop to provide pasture for late fall and early spring grazing. Considerable barley and oats are grown also. Fruit may be grown anywhere in the County where the soils are well drained, but the principal fruit-growing areas are along the slopes adjacent to Seneca and Cayuga Lakes, where the frost-free period is longer than elsewhere. Vegetable farming is practiced to a great extent in areas of muck soils, reclaimed by draining of marsh areas. The most important vegetable crops are potatoes, celery, sweet corn, onions, and beans.

Table 2.—Temperature and precipitation data for Romulus, N. Y. for the period of record through 1930[a]

Month	Temperature (°F.)					Precipitation (inches)		
	Mean	Highest	Lowest	Average maximum	Average minimum	Mean	Average number of days with 0.01 or more	Average snow-fall
June	66.3	96	35	77.7	54.9	3.28	7	0
July	71.3	98	41	82.4	60.3	3.10	8	0
August	69.0	98	37	79.6	58.3	2.99	7	0
Summer	68.9	98	35	79.9	57.8	9.37	22	0
September	62.6	97	32	73.4	52.2	2.42	6	0
October	51.4	88	21	61.0	42.2	2.85	8	.3
November	39.3	74	3	47.1	31.6	2.21	7	3.4
Fall	51.1	97	3	60.5	42.0	7.48	21	3.7
December	28.8	65	−18	36.1	21.4	2.01	7	10.9
January	24.6	70	−19	32.7	16.7	2.08	8	11.8
February	23.7	65	−17	32.0	15.4	1.82	7	12.5
Winter	25.7	70	−19	33.6	17.8	5.91	22	35.2
March	33.6	84	− 5	42.9	24.5	2.39	7	10.0
April	45.4	88	9	56.4	35.2	2.48	8	4.3
May	57.3	93	25	68.5	46.1	3.34	9	.1
Spring	45.4	93	− 5	54.9	35.3	8.21	24	14.4
Year	47.8	98	−19	57.4	38.2	30.97	89	53.3

[a] Compiled from Climatic summary of the United States; Section 80, Central New York: U. S. Weather Bur., 1935.

INDUSTRY

In 1939 there were 22 manufacturing establishments (New York State Dept. of Commerce, 1946) in Seneca County employing an average of 1,418 workers. The principal industrial groups were food and food products, machinery, textile-mill products, and printing and publishing. The pre-World War II value of industrial products was approximately 5.5 million dollars, and during the war years of 1940 to 1944 the industries of Seneca County processed nearly 23 million dollars of supply contracts. Most of the industrial establishments are in the vicinity of the villages of Seneca Falls and Waterloo.

GEOLOGY

GEOLOGIC HISTORY

Seneca County was once a part of the Appalachian geosyncline, a wide trough that bordered an ancient land mass to the east, known as Appalachia. The geosynclinal trough was occupied periodically by shallow seas into which both clastic and nonclastic sediments derived from the weathering of the ancient land mass were carried and deposited by streams. The nature of the sedimentation was varied and reflected the physical events that transpired throughout the Paleozoic era.

The deposition of sediments in the Paleozoic era was stopped by the Appalachian revolution. As a result of the crustal deformation during the Appalachian revolution, a series of overturned folds and thrust-fault structures were produced along the eastern margin of the former geosyncline. The intensity of the folds diminished westward, and the sedimentary beds in Seneca County have been folded only to a mild degree.

Throughout the Mesozoic era the forces of weathering and gradation gradually reduced the region to an essentially flat plain or peneplain. During the Cenozoic era the region was uplifted once again and streams began eroding with renewed vigor. The uplifted peneplain was gradually dissected and the major streams developed a pattern of north-south-trending valleys. Later continental glaciation modified the pre-Pleistocene drainage, in some cases to a considerable degree.

The continental ice sheet that advanced upon New York and extended into Pennsylvania during Pleistocene time had its center in eastern Canada. The ice was thick enough to cover the highest hills, and was thickest over the major valleys. The erosive action of the glacier was concentrated particularly along the northward-sloping preglacial valleys of Cayuga and Seneca Lakes, the axes of which lay parallel to the direction of movement of the ice. When the ice melted the heaviest deposition of glacial materials was in those deepened valleys, and the present thickness of the glacial deposits in Seneca County decreases as the divide separating the Finger Lake troughs is approached. It is believed that there were at least two periods of glaciation in Seneca County. Since the withdrawal of the last ice sheet, postglacial erosion in places has reexcavated some of the preglacial or interglacial valleys and at the same time has formed postglacial valleys that drain the chief Finger Lake troughs. Cascades and falls mark places where the postglacial streams have cut through the thin mantle of drift and re-exposed the underlying rocks. The lower parts of many of these valleys, however, are still covered by glacial deposits of Pleistocene age and Recent alluvium.

STRUCTURAL GEOLOGY

Seneca County is underlain by sedimentary rocks of upper Silurian through Upper Devonian age. These rocks have an aggregate thickness of more than 2,000 feet. A generalized stratigraphic column for Seneca County is shown in table 3 and the bedrock geology is shown on plate 2. The regional dip of the formations is approximately 30 to 35 feet per mile southwest and this coupled with a gradual rise in topography results in the successive exposure of younger formations from north to south (pls. 2 and 3). Steeper dips, and occasional reversals in the direction of dip, were observed where local anticlinal or synclinal structures exist. These shallow structural features probably represent diminished Appalachian foreland folds that trend approximately east-west and are superimposed on the nearly horizontal rock strata.

Two distinct sets of joints that persist throughout the area were measured. The main set, herein termed dip joints, appears to be in the form of two conjugate shear planes that intersect and form acute angles ranging from 10° to 30°. The mean direction of the dip joints ranges from N. 15°-30° E. to N. 30°-45° W. Another set of joints, herein termed strike joints, trend from N. 60° E. to 70° E. and are at right angles to the dip joints. The strike joints appear to be the result of tensional forces and they are generally parallel there being only an occasional variation in trend. Spacing of the joints observed ranged from 1 inch to 4 feet. Where measurements could be made the dip of the joint planes ranged from 46° to nearly vertical. Except for those formed in the limestone beds, the joint openings were very narrow. Most of the joints and fractures in the beds of shale were filled with clay or fine silt.

Table 3.—Geologic formations in Seneca County, N. Y. and their water-bearing properties

Age: System	Age: Series	Geologic formation	Maximum thickness (feet)	Character of material	Water-bearing properties
Quaternary	Recent	Alluvium	50−	Predominantly coarse gravel and sand consisting in part of limestone and shale fragments, poorly sorted, and deposited principally along lower end of valleys discharging into the Finger Lakes.	Unimportant as an aquifer, owing to thinness and lack of areal distribution. Deposits permeable, as indicated by disappearance and reappearance of streams in lower ends of valleys. No well records obtained.
	Pleistocene	Glacial drift	268+	Till—heterogeneous admixture of nonstratified or poorly stratified material ranging in size from clay to boulders. Highly variable changing in consistency within short distances both vertically and horizontally. Locally water sorted.	Extensively tapped by dug wells, particularly in northern third of county. Permeability highly variable, as indicated by the range in yields from 0.5 to 75 gallons per minute; average yield 7 gallons per minute. Water is hard.
				Outwash—sorted deposits ranging in size from clay to boulders and in many places stratified and cross bedded. Limestone and calcareous shale fragments abundant.	Yields range from 3 to 230 gallons per minute but average 33 gallons per minute. Greatest yields from deeply buried sand and gravel. Water is generally hard.
Devonian	Upper Devonian	Wiscoy shale	250±	Thinly bedded arenaceous shale with occasional sandstone layers. Poorly exposed, thickness in Seneca County estimated.	Drilled wells range in depth from 45 to 265 feet and average 91 feet. Yields range from 1.5 to 12 gallons per minute and average 5 gallons per minute. Yields, in general are smaller than from other consolidated rocks in Seneca County but quality of water is good. Lowest content of dissolved solids from consolidated rocks; average hardness 223 parts per million.
		Nunda sandstone	85±	Thin, irregularly bedded sandstone, generally gray in color with slight greenish cast, and occasionally intercalated with thin shaly beds. Poorly exposed, thickness in County estimated.	
		West Hill formation	600±	Sandy, dark-gray to black fissile shale, frequently iron stained. Extremely friable and medium gray in color when weathered. Occasional dense greenish-gray sandstone layers. Parallel joint, N. 72° E. and N. 10° W., 1.5 to 4.0 feet apart. Where exposed, joint planes tightly sealed or filled with clay or silt.	
		Grimes sandstone	75±	Thick sandstone beds, greenish gray in color, poorly exposed in County.	
		Hatch shale	350−	Light to dark-gray or black shale becoming more arenaceous in upper part of section, and interbedded with occasional hard gray sandstone beds 2 to 30 inches thick. Parallel joint pattern, similar trends, tightly sealed or filled with fine clastics.	Drilled wells range in depth from 20 to 368 feet and average 78 feet. Yields range from less than 1 to 50 gallons per minute and average 6.5 gallons per minute. Several wells have small artesian flow. Some well failures during periods of prolonged drought or continuous pumping. Dissolved solids and hardness average 494 and 373 parts per million, respectively. High iron content and hydrogen sulfide often present.
		Cashaqua shale	220 to 250	Gray calcareous thinly-bedded shales at base, becoming more arenaceous and flagstone-bearing in upper part of section. Upper beds more resistant, forming falls and cascades along several of the ravines. Parallel joints with trends of N. 70° E., N. 25° W. and N.-S., spaced fraction of an inch to 6 feet, generally tightly sealed or filled where exposed.	

Table 3.—Geologic formations in Seneca County, N. Y. and their water-bearing properties (Continued)

Age: System	Age: Series	Group	Geologic formation	Maximum thickness (feet)	Character of material	Water-bearing properties
Devonian (Continued)	Upper Devonian (Continued)	Genesee group	West River shale	75−	Generally dark-gray to black shale with infrequent calcareous shale layers, concretions or thin calcareous sandstone beds of small areal extent.	Yields small supplies to few wells, owing to low permeability, small recharge, and limited outcrop area. Wells range in depth from 20 to 175 feet. Yields range from less than 1 to 20 gallons per minute and average 7 gallons per minute. Water is hard and contains some iron.
			Genundewa limestone lentil of Geneseo shale	..	Soft, friable, gray to black shale with flat, fossil-bearing concretions at base. Grades into thin nodular and fossiliferous (*Styliolina fissurella*) limestone in Ontario County. Good stratigraphic marker.	
			Geneseo shale	85±	Dense, black, thinly laminated shale becoming light gray and very friable upon weathering. Characterized by closely spaced intersecting joints with trends of N. 30° W., N. 75° E., and N. 5°-15° E. Limestone concretions present in lower beds.	
	Middle Devonian		Tully limestone	15	Compact, hard, dense, and finely textured, black limestone when fresh, light bluish gray when weathered. Beds 2 to 4 feet thick with occasional shale partings 1 to 3 inches thick. Lower beds more massive, upper beds highly fractured. Brittle, breaking into angular fragments upon impact of hammer. Exposed joints, fractures, and bedding planes widened by solution. Good horizon marker.	Hydrologic properties similar to those of the Hamilton group.
		Hamilton group	Moscow shale	140±	Lower two-thirds of section is a fossiliferous, soft gray calcareous shale; upper third highly friable but less calcareous and fossiliferous. Staining by iron oxide very common. Concretions present in greater abundance in lower beds, but irregular calcareous masses occur throughout section. Joints parallel, tightly sealed, trending N. 65° E. and N. 25°-30° W.	Extensively used for domestic and stock supply but wells are affected by drought conditions. Water contained in bedding planes and fractures. Yields range from less than 1 to 60 gallons per minute and average 11 gallons per minute. Wells range in depth from 18 to 665 feet and average 105 feet. No apparent correlation between yield and depth of wells. Dissolved solids and hardness average 519 and 393 parts per million, respectively; iron content averages 3.63 parts per million.
			Ludlowville shale	140±	Lower beds are thinly laminated, light-colored, fossiliferous, shaly passage beds; overlain by hard calcareous black shales 5 to 12 inches thick and rich in corals and brachiopods; hard layers responsible for falls and cascades. Middle beds are less fossiliferous, soft gray arenaceous shales, rich in concretions, calcareous lenses, and occasional thin sandstone layers. Upper beds (Tichenor limestone member) are thin, irregularly bedded gray shales becoming light blue gray upon exposure, calcareous, coarsely textured, and fossiliferous. Joints parallel, 2 to 20 inches apart, well developed but tight.	
			Skaneateles shale	185±	Basal beds composed of dark fissile shale. Upper shale more calcareous, grayish to bluish impure limestone layers. Joint pattern N. 75° E. and N. 30° W.; diagonal joints N. 50° E. Joints sealed, parallel and spaced 6 inches to 4 feet apart.	
			Marcellus shale	50	Black, slatelike, bituminous shale with occasional limestone layers in sequence, and containing zones rich in iron sulfides or calcareous concretions, often with septarian structures; very fissile, iron-stained and gray when weathered. Joint pattern N. 25° W., N. 65° E., 1 inch to 4 feet apart.	

Table 3.—Geologic formations in Seneca County, N. Y. and their water-bearing properties (Concluded)

Age: System	Age: Series	Geologic formation	Maximum thickness (feet)	Character of material	Water-bearing properties
Devonian (Continued)	Lower or Middle Devonian	Onondaga limestone	80	Dark, dense-textured limestone becoming bluish-gray upon exposure. Beds up to 3 feet in thickness, frequently separated by finely laminated shale partings. Joints, bedding planes, and fractures show marked effects of solution. Joint trends N. 70°-75° E., N. 30° W., N. 50° E. Fossils abundant.	Best bedrock aquifer considering both quantity and quality of water. Yields range from 1 to 200 gallons per minute and average 33 gallons per minute. A few wells flow without being pumped. Best production from outcrop area, especially in places where the limestone is overlain by permeable glacial outwash deposits. Wells range in depth from 40 to 465 feet and average 112 feet. Dissolved solids and hardness average 557 and 317 parts per million, respectively. Water contains small amounts of hydrogen sulfide.
	Lower Devonian	Oriskany sandstone	½	Represented in County as thin layer of carbonaceous matter 3 to 6 inches thick, containing pebbles from underlying water lime, also grains of sand. Sand content is greatest in the eastern part of the County.	Unimportant as an aquifer, owing to thinness or absence of formation.
Silurian	Upper Silurian	Manlius limestone	Very thin	Formation consists of limestone and water lime; reported to pinch out in vicinity of Waterloo. Fossils, mainly brachiopods, abundant.	Few well records obtained. Owing to thinness, individual formations are unimportant as aquifers. Collectively, the records indicate a range in yield from 4 to 30 gallons per minute with an average yield of 14 gallons per minute. Some artesian flow reported. Wells average 95 feet in depth. Dissolved solids and hardness in single analysis were 1,842 and 1,000 parts per million, respectively. Water in several wells reported to contain hydrogen sulfide and iron in noticeable amounts.
		Rondout limestone	10	Dark, shaly, magnesian limestone, poorly exposed in County. Thickness increases eastward. Fossils scarce.	
		Cobleskill dolomite	8	Hard, dark limestone becoming brown upon prolonged exposure. Upper beds consist of a compact coralline limestone. Formation poorly exposed in County.	
		Salina formation: Bertie limestone member	30−	Hard, dense-textured limestone when freshly fractured; light gray to bluish upon exposure. Fractures are irregular and conchoidal in character. Beds 2 to 10 inches in thickness and separated by thin friable shale partings. Fossils rare.	Most productive formation in County; yields range from 5 to 400 gallons per minute and average 45 gallons per minute. Quality of water is generally poor; available analyses of water show dissolved solids and hardness average 1,481 and 865 parts per million, respectively; water frequently contains hydrogen sulfide. Chloride and sulfate content often increase with depth. Depth of wells averages 160 feet.
		Salina formation: Camillus shale member	700±	Only upper beds of member crop out in County, consisting largely of calcareous shale layers with occasional thin dolomitic limestone beds, and separated by thin layers of friable shale. Beds are as much as 4 inches in thickness, highly fractured and characterized by irregular bedding planes. Pale green to light gray, becoming medium to dark gray upon weathering. Voids numerous, irregular in shape, and often lined with calcite crystals. Uppermost beds highly gypseous. Joints N. 10°-15° E. and N. 65°-75° E. Fossils rare except for occasional ostracods.	

CONSOLIDATED ROCKS

Salina Formation

The Camillus shale member of the Salina formation is the oldest sedimentary rock cropping out in Seneca County. The Camillus crops out in an east-west zone across the northern part of the County. The lower part of the member is composed of soft shale interbedded with thin layers of dolomitic limestone, and the upper part of gypseous shale. The few exposures of the Camillus shale member within the County are principally along the beds of the northward-flowing streams such as Black Brook and Pond Brook.

An exposure of the Camillus shale member of the Salina formation along a road cut 1½ miles southeast of Crusoes Corners, consists chiefly of layers of calcareous shale about 4 inches thick, interbedded with thin layers of a more friable shale. At this outcrop, the Camillus is irregularly bedded and highly fractured, and contains numerous voids, many of which are lined with small crystals of calcite.

The Bertie limestone member of the Salina formation, an impure limestone, lies directly over the Camillus shale member in Seneca County. There are few exposures of the Bertie limestone member in Seneca County and they are found mainly along the south bank of the Seneca River just east of the village of Seneca Falls. The Bertie is a hard dense limestone, dark-colored when freshly broken, and light gray with a bluish cast when weathered. It is fractured by many irregular joints. The beds range in thickness from 2 to 10 inches and usually are separated by thin partings of friable shale. According to Luther (1909, pp. 8-9), the Bertie contains a few fragmentary remains of a crustacean fauna. The Bertie limestone member is estimated to be about 25 feet thick.

Cobleskill Dolomite and Rondout and Manlius Limestones

The Cobleskill dolomite and the Rondout and Manlius limestones are the youngest rocks of Silurian age in Seneca County and they have been grouped together and shown as a single unit on the geologic map (pl. 2). According to Luther (1909, pp. 9-10), the Cobleskill in the Seneca County area is a dense limestone about 8 feet thick. Fresh samples are dark gray but the rock weathers to a brown color upon prolonged exposure. The upper 7 feet consists of compact coralline limestone. The Rondout limestone in Seneca County, according to Luther (1909, pp. 9-10), is about 10 feet thick and consists chiefly of a dark shaly dolomitic limestone. The Manlius limestone in Seneca County is very thin and is reported (Luther, 1909, pp. 9-10) to pinch out in the vicinity of Waterloo. It consists of limestone and water lime. When freshly broken it is dark in color, but upon exposure it assumes a bluish-gray color which brings out the fine straticulation that is characteristic of the formation. Fossils are abundant and consist mainly of brachiopods.

Oriskany Sandstone

The basal formation of the Lower Devonian series in the Finger Lake region is the Oriskany sandstone. It consists of a thin layer of carbonaceous material 3 to 6 inches thick, which contains grains of sand and pebbles of the underlying Rondout limestone. It is believed that the sandstone increases in thickness both south and east of Seneca County.

Onondaga Limestone

The Onondaga limestone crops out in a belt of rocks trending west-northwest and east-southeast across Seneca County. Its area of outcrop is divided by the Seneca River into two almost equal parts. The Onondaga is a dense limestone, dark when freshly broken but distinctive bluish gray when weathered. It is approximately 80 feet thick and consists of individual beds as much as 3 feet thick in places separated by finely laminated partings of carbonaceous shale. The limestone contains also layers of black or grayish-blue chert which stand out in relief when weathered. The dominant joint patterns in the Onondaga trend N. 25°-35° W. and N. 70°-75° E. The joint openings, where well developed, are relatively wide and along stream beds have been enlarged by solution. At some localities the Onondaga limestone has been heavily fractured. Fossils are very abundant, and numerous species of crustaceans, cephalopods, gastropods, brachiopods, and corals have been observed in the limestone.

Hamilton Group

Marcellus shale.—The Marcellus shale (including beds equivalent to the Cardiff shale of New York State reports) is the oldest formation of the Hamilton group. It consists principally of shale and contains an occasional bed of limestone. The Marcellus is a black slatelike bituminous

shale which contains layers rich in iron sulfide and calcareous concretions, the concretions often displaying fine septarian structure. When freshly broken, the Marcellus has a black bituminous appearance, but when weathered it is gray. It is very fissile, breaking readily into small, thin fragments which are often stained with iron oxide. The joints strike N. 25° W. and N. 65°-70° E. and are spaced from 1 to 44 inches apart. In Seneca County the Marcellus shale is about 50 feet thick.

Skaneateles shale.—The Skaneateles shale, which is approximately 185 feet thick in Seneca County, overlies the Marcellus shale. The basal beds are dark and fissile, but in the upper beds the shale gradually becomes more calcareous and assumes a grayish to bluish color. The upper beds are exposed in a quarry about 0.3 mile west of Fayette. The joints exposed in the quarry strike N. 75° E. and N. 30° W.

Ludlowville shale.—Overlying the Skaneateles shale is the Ludlowville shale, which is about 140 feet thick in Seneca County. The older beds of the Ludlowville consist of hard calcareous layers rich in corals and brachiopods and, because of their resistance to erosion, are responsible for the falls and cascades in several of the ravines and gorges. These layers consist of dense thin-bedded limestone which is black when freshly exposed but which becomes medium gray to light gray when weathered. The very abundant and more resistant corals and brachiopods stand out in relief conspicuously on weathered surfaces.

The middle beds of the Ludlowville shale, lying above the hard calcareous zone, consist of thin layers of soft sandy shale which contain calcareous lenses and an occasional layer of sandstone. The youngest beds of the Ludlowville are more calcareous and coarser in texture than the middle beds. They are gray when fresh and become light gray with a bluish tinge upon prolonged exposure. The upper part of the Ludlowville is thin-bedded, individual layers usually being only half an inch to an inch thick. Fossils are numerous and the following faunas have been reported (Luther, 1909, pp. 19-21): worms, crustaceans, ostrocods, gastropods, cephalopods, brachiopods, corals, crinoids, and lamellibranchs.

The Tichenor limestone member of the Ludlowville shale, lying below the Moscow shale of the Hamilton group, is an excellent index horizon in the upper Paleozoic sedimentary rocks of central New York. In Seneca County the Tichenor limestone member defines the upper limit of the Ludlowville shale, and because of its resistance to erosion it produces small cascades or falls in some of the ravines in the area. The Tichenor is composed of layers of dense light-colored limestone that are several inches thick, overlain by a hard calcareous shale about 5 feet thick. The layers of limestone contain many fragments of crinoids.

Moscow shale.—The lower two-thirds of the Moscow shale is a soft gray calcareous shale containing an abundance of fossils. The upper or younger part of the Moscow shale is dark, highly friable, and less calcareous and fossiliferous than the lower two-thirds. Weathered surfaces generally are medium to light gray and may be stained by iron oxide. The upper beds of this shale crop out at the abandoned quarry approximately 2 miles north-northeast of Ovid. The Moscow shale which, in Seneca County is approximately 140 feet thick, is broken by many joint openings which strike N. 65° E. and N. 25°-30° W.

Tully Limestone

The Tully limestone overlies the Moscow shale. It is black when freshly broken, but light gray when weathered. Individual layers are 2 to 4 feet thick and in places are separated by partings of shale 1 to 3 inches thick. The upper 4 feet of the limestone beds are more highly fractured than the lower layers which have a more massive appearance. The Tully limestone is a dense, hard rock but is very brittle and breaks readily into angular fragments. The entire thickness of the Tully limestone, 15 feet, is exposed along Simpson Creek near Willard.

The joints and openings along bedding planes in the Tully have been enlarged by solutional activity, with the result that several small springs discharge from the limestone where it is confined between shales, particularly in the ravines and gorges in the southern part of Seneca County. The major joint system in the Tully strikes N. 5° E.

Genesee Group

Geneseo shale.—Overlying the Tully limestone is the Geneseo shale, the basal formation of the Genesee group. In Seneca County the Geneseo shale is about 85 feet thick. In general, it is a dense rock which is thinly laminated. Fresh exposures are black but these change to light gray

when they become weathered. The Geneseo shale is highly jointed, and the joints have an intersecting pattern which is effective in producing small but sheer cliffs. The joints are primarily in two systems, striking N. 30° W. and N. 75° E. Exposures of the Geneseo may be found at nearly all localities where the Tully limestone crops out.

Genundewa limestone lentil.—In Seneca County the Genundewa limestone lentil of the Geneseo shale is a calcareous rock, the basal beds of which are rich in flat concretions that are fossiliferous. The best exposures of the Genundewa in Seneca County is along a cut of the Lehigh Valley Railroad near the village of Willard. There the Genundewa is a gray to black rock, soft and very friable, in which the flat concretions stand out conspicuously. It is about 10 feet thick.

West River shale.—Overlying the Genundewa limestone lentil of the Geneseo shale is the West River shale, which is 65 to 75 feet thick and is the uppermost member of the Genesee group. The West River shale is exposed in the ravines in the east slope of Seneca Lake Valley. In general, the West River is dark gray to black and contains occasional layers of calcareous shale and calcareous sandstone of small extent. Fossils are rare, especially in the darker bituminous horizons. The West River is the youngest formation in the Genesee group.

Cashaqua Shale

The Middlesex shale, stratigraphically below the Cashaqua shale, is here included with the Cashaqua. The Middlesex shale is reported to have a thickness of about 60 feet in the vicinity of Lodi (Bradley and Pepper, 1938). The Cashaqua shale, a thinly banded rock, has a total thickness of approximately 220 to 250 feet in Seneca County and is composed of gray calcareous shale. The basal beds contain thin layers of sandstone and the upper beds are interlayered with flagstone. The contact with the overlying Hatch shale is not easily recognized owing to the presence of thin layers of sandstone in both the Cashaqua and the Hatch. Fossils are generally lacking except for rare zones where a meager fauna is present. Three joint systems, trending N. 70° E., N. 25° W., and N.-S., were observed at outcrops of the Cashaqua shale in Seneca County. In most instances, the jointing was parallel and well defined, the spacing ranging from a fraction of an inch to about 6 feet.

Hatch Shale

The Rhinestreet shale (stratigraphically below the Hatch shale) has been recognized in Seneca County near Mill Creek about four miles south of Lodi (Bradley and Pepper, 1938), and is included in the Hatch shale in this report. The Hatch shale consists of 300 to 500 feet of shale and interbedded flagstone. In general, the Hatch shale ranges in color from light to dark gray or black. The basal beds of the Hatch shale are composed of soft rocks, whereas the upper beds are hard sandy rocks. Interbedded with the layers of shale are layers of hard gray sandstone that range in thickness from 2 to 30 inches. The fauna of the Hatch shale is not very abundant and consists chiefly of a few specimens of brachiopods and cephalopods.

Grimes Sandstone

The Grimes sandstone is poorly exposed in Seneca County. Luther (1909, p. 32), has estimated the thickness of the Grimes sandstone in Seneca County to be about 75 feet. The Grimes, where exposed outside the County, consists largely of thick beds of sandstone containing brachiopods.

West Hill Formation

Overlying the Grimes sandstone is the West Hill formation, which consists chiefly of shales interbedded with thin flagstones. Only part of the formation is exposed in Seneca County, but the entire thickness is estimated to be 600 feet. The best exposure in Seneca County is at a quarry a mile northeast of Lodi Center. There, the West Hill consists of about 20 feet of thin-bedded gray to black shale capped by less than a foot of greenish-gray sandstone. Joint patterns in the West Hill formation are well developed and strike N. 10° W. and N. 72° E.

Nunda Sandstone

The only exposures of the Nunda sandstone in Seneca County are along an east-west road in the vicinity of Butcher Hill. The Nunda sandstone consists of thin irregularly bedded layers of sandstone generally gray in color but having a slight greenish cast. In places a thin layer of shale is interbedded with the layers of sandstone. Goldring (1931, p. 402) indicates the thickness of the Nunda to be from 85 to 100 feet at High Point, near Naples, Ontario County. The exposures of the Nunda sandstone examined in Seneca County were unfossiliferous.

Wiscoy Shale

The Wiscoy shale is very poorly exposed in Seneca County and most of the outcrops are along an east-west road just south of Butcher Hill. An outcrop was found also in a cut along an east-west road north of Butcher Hill. At these few exposures the Wiscoy consists mainly of thin beds of arenaceous shale interbedded with layers of sandstone. Its thickness in Seneca County is undetermined, but at Prattsburg, in Steuben County, it is reported to range from 250 to 600 feet. Fossils are very sparse in the Wiscoy shale.

UNCONSOLIDATED DEPOSITS

Glacial Drift (Pleistocene)

The Wiscoy shale is the youngest consolidated rock in Seneca County. Resting upon it and upon all the other bedrock formations is a mantle of unconsolidated material which was deposited beneath and in front of the last ice sheet during the Pleistocene epoch. On the average, the Pleistocene drift in the northern part of Seneca County is much thicker than that in the remainder of the County. The thickest deposits are in the valleys carved in bedrock by preglacial and interglacial streams, particularly the buried valleys that extend north of the Cayuga and Seneca Lake troughs. The glacial drift consists of coarse stratified sands and gravels deposited by streams, fine-grained silts and clays deposited in lakes, and till, a heterogeneous mixture of fragments ranging in size from boulders to clay particles. The latter is the most common type of glacial deposit in Seneca County, forming a thin mantle over most of the central and southern parts. The glacial deposits are described more fully beyond, under the section, "Ground water, occurrence in unconsolidated deposits."

Alluvium (Recent)

Alluvial clays, silts, sands and gravels are found associated with the larger streams. The deposits, laid down in post-Pleistocene time, are narrow and confined to the immediate vicinity of the streams which formed them. The alluvium consists of reworked material derived from till and other glacial deposits.

GROUND WATER

SOURCE

The ground water in Seneca County is derived almost wholly from precipitation within the County. The precipitation is unequally distributed throughout the year, the bulk of it falling during the warmer months (see tables 1 and 2). One inch of rainfall over an area of 1 square mile provides about 17 million gallons or 72,300 tons of water. Assuming an average annual precipitation of 30.97 inches and an area of 330 square miles for the entire County, then the total precipitation upon Seneca County is about 180 billion gallons or 740 million tons per year. It is obvious that only a portion of this water finds its way beneath the surface to become ground water. The amount of water that is absorbed by the ground is affected by several interrelated factors such as (1) the porosity and permeability of the overburden and the bedrock, (2) the slope of the land, (3) the amount and kind of vegetal cover, (4) the amount and intensity of precipitation, and (5) the position of the water table and the amount of soil moisture.

In a detailed study of ground-water resources of an area it is important to make a continuous inventory of the various losses and gains in the amount of water stored in the ground. The losses may be classified as hydraulic and evaporative discharge. Hydraulic discharge includes seepage from springs and discharge from wells. Evaporative discharge includes consumption of water by plants and evaporation of water from the soil.

OCCURRENCE

Principles

Water that occurs in pore spaces or other interstices in rocks is termed subsurface water. This water lies in the zone of fracture and is differentiated from the magmatic or internal water that exists deep within the earth in the zone of rock flowage. In the latter zone there are no voids and the water is in molecular association with other earth materials. It is the water in the zone of fracture, therefore, that is of prime importance to man.

Subsurface water occurs in the zone of saturation and the zone of aeration. The plane of separation between the two zones is known as the water table (fig. 3). The zone of saturation lies

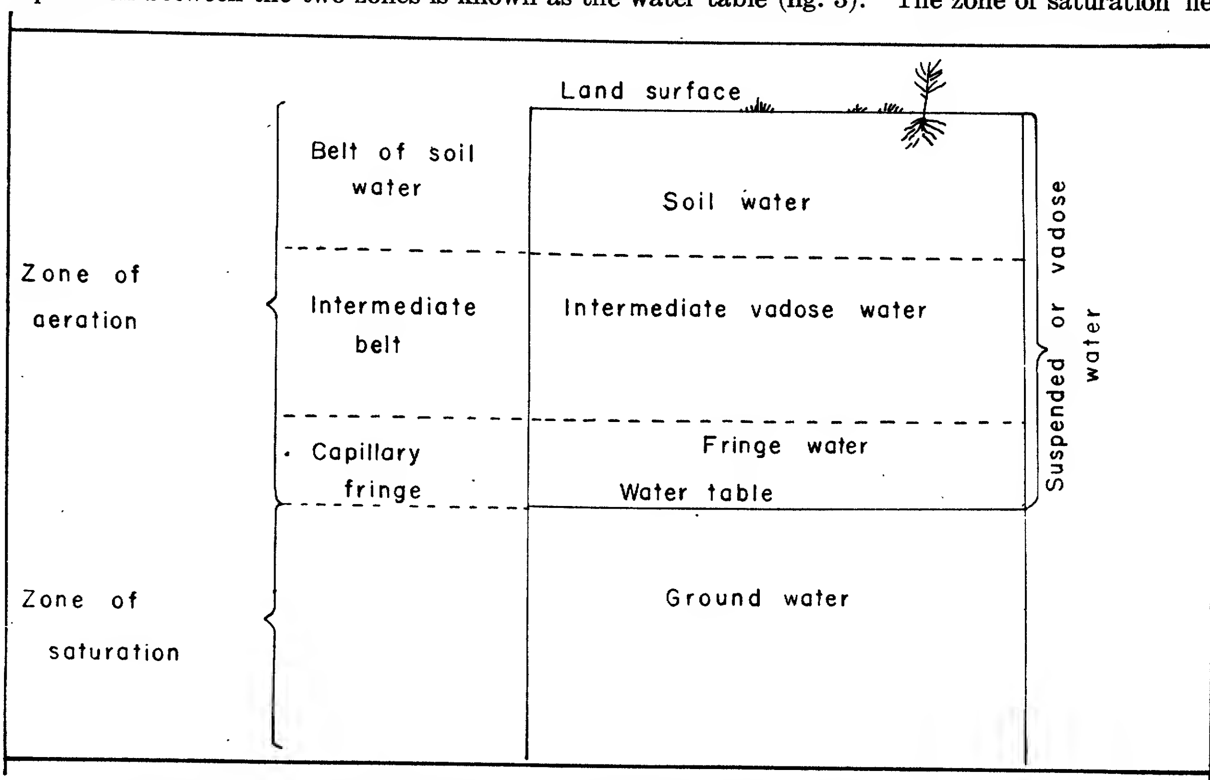

Figure 3.—Diagram showing zones of water below the land surface. (After Meinzer)

below the water table and in this zone all the interstices are filled with water. Water within the zone of saturation is called ground water. The zone of aeration lies above the water table and in this zone the interstices usually are not filled with water, except for periods of short duration. In contrast with that in the underlying zone of saturation, the water in the zone of aeration is not under hydraulic pressure, but rather is held by molecular attraction, known as "capillary forces." Voids that are not occupied by water are occupied by air or other gases.

The zone of aeration is divided into subzones known as the capillary fringe, the intermediate belt of suspended or vadose water, and the belt of soil water (fig. 3). The capillary fringe overlies the zone of saturation. The smaller openings or voids in this fringe are filled with water held up by capillarity against the pull of gravity. The thickness of the fringe zone depends upon the height to which water will rise in the soil openings, the height of the column of water being proportional to the diameter of the opening. Thus, the texture of the rock or soil is important in determining the thickness of the capillary fringe. If the openings are small, as is true in fine sand, the capillary-fringe zone is thick; if the openings are large, as in a coarse gravel, then almost no fringe may exist. In the process of well drilling, the penetration of this zone does not result in a flow of water into the well because water in the fringe zone is held by capillary forces and is not free to move under the influence of gravity. However, drillers regard the increased moisture content of the material penetrated as an indication that the water table is being approached.

Directly beneath the surface of the ground is the belt of soil water, and it is from this zone that plants obtain the much-needed moisture for their growth. The particles making up the soil retain the water as a thin film held by molecular attraction. The water is sometimes referred to as pellicular or film water. Water from this belt in the zone of aeration is returned to the atmosphere by both the transpiration of plants and by direct evaporation from the soil.

The space between the lower limit of the belt of soil water and the upper limit of the capillary fringe forms an intermediate belt that is thick where the depth to the water table is great but thin where the water table is near the surface—where, indeed, such a belt may be entirely lacking. Both the belt of soil water and the capillary fringe are limited in thickness by definite local conditions. The belt of soil water is limited by both the character of the vegetation and the texture of the rock or soil, and the capillary fringe is limited by the texture of the rock or soil. The intermediate belt, however, is not thus limited. It is the residual part of the zone of aeration.

The term "porosity" denotes the total volume of voids or other open spaces that are contained within a rock. The quantity of water that can be stored beneath the land surface, therefore, is dependent upon the porosity of the rocks. Porosity is usually expressed as a percentage, and it includes all the voids whether or not they are interconnected.

Although the porosity of a rock indicates the total volume of pore space available for storing water, the term "specific yield" indicates that amount of water that will drain out of a rock by gravity. The specific yield of a rock or soil, with respect to water, is the ration, expressed as a percentage, of (1) the volume of water that, after being saturated, it will yield to gravity to (2) its own volume. It is the measure of the water that is free to drain out of a material under natural conditions.

The factors that may influence the porosity of rocks or soils are (1) the degree of cementation, (2) the size of constituent grains, (3) the arrangement of grains, (4) the shape of grains, and (5) the uniformity of grain size (Meinzer, 1923, pp. 3-4). The amount of water that is available, and the rate at which it may be recovered, are largely determined by the permeability and the storage capacity of the water-bearing formations. Recovery of all water from water-bearing beds is not possible because of the molecular attraction between the mineral grains and the water. Thus, in the evaluation of ground-water conditions for any area, the physical properties of the bedrocks and overburden are of prime importance.

Consolidated Rocks

Nearly all the rocks in the northern third of Seneca County are limestone, the Camillus shale member of the Salina formation being the only prominent nonlimy rock in the area (pl. 2). In the areas where these rocks, which dip gently to the south, have been covered by a thick mantle of glacial deposits, many successful wells have been drilled in bedrock. The limestone beds in the area are heavily jointed and fractured and in many instances show marked effects of solutional cavity. The Camillus shale member is badly fractured and has many irregularly shaped voids. These openings create a greater storage capacity and are more favorable to movement and recovery of ground water than are those in most shales.

The formations above the Camillus shale member of the Salina formation up to and including the Onondaga limestone are the most prolific aquifers in the County. These formations underlie that part of the County that is covered by thick deposits of drift and which has an imperfect drainage system. All these factors make for conditions favorable to the recharge of ground water to bedrock in the northern part of the County.

The southern two-thirds of the County is underlain by Middle and Upper Devonian sedimentary rocks, which consist largely of beds of shale and flagstone, interbedded with a few layers of sandstone and limestone of limited extent (pl. 2). The shales are relatively impermeable and absorb, transmit, and yield water very slowly. Although the porosity of some shales may be high, the small size of the openings between constituent grains inhibits rapid transmission of water. The joints and other secondary openings in the shales are generally very narrow or are filled with fine silt and clay. The number of such openings diminishes with depth. Inasmuch as the shale beds are composed dominantly of insoluble clay minerals, there is little opportunity for the widening of secondary openings through solutional activity.

The storage capacity of the shales is far more limited than that of the older limestones to the north. The low permeability of the shales tends to inhibit downward seepage of water from the surficial deposits. Where such beds crop out in steep slopes, there generally are springs or seeps resulting from lateral movement of water thus prevented from going deeper. The conditions for recharge to the shales and flagstones are rather unfavorable because the edges of beds capable of absorbing and carrying substantial amounts of water crop out on steep slopes, and there is no thick cover of glacial drift that might feed water into the strata. By comparing the configuration of the land surface with that of the bedrock (pl. 1 and 4), it may be noted that the interbedded shales and flagstones form the upland or divide area of Seneca County, and that the slope of the bedrock and the land surface increases near the Finger Lakes. The steep slopes favor rapid drainage of surface waters and thereby decrease the opportunity for absorption of water by the glacial drift. Although the drift itself is considerably more permeable than the underlying shale, it is too thin to hold large quantities of water for gradual recharge of the bedrock.

The rock-contour map (pl. 4) shows, in general, the configuration of bedrock as it would appear if the glacial deposits were stripped away. The contours representing this surface have been drawn on the basis of the altitude of the bedrock at about 550 points in Seneca County, determined from exposures and well records.

The rock-contour map strongly suggests the presence of a northward extension of the bedrock valleys of both Seneca and Cayuga Lakes. The extensions are now buried by Pleistocene deposits. Not enough data on bedrock have been obtained from well records and field exposures to show the details of the morphology of the buried valleys. Furthermore, a part of each valley extends into adjacent countries for which, at present, few data are available. The rock contours show that the northward extension of Cayuga Lake Valley divides in the extreme northern part of Seneca County. The contours also suggest a cross channel or lowland that extends across the County, joining the extended buried parts of the Finger Lake valleys approximately beneath the course of the Seneca River. There is the suggestion that this buried channel may have existed as two tributary valleys, one trending eastward and joining the main north-south valley of Cayuga Lake, and the other trending westward and joining the northern extension of Seneca Lake valley. A shallow buried divide between the two tributary valleys is suggested by the slightly higher altitude of the bedrock in the vicinity of Waterloo. South of the Seneca River the buried lowland area swings southeastward in the form of a broad arc and extends beyond the settlement at Canoga where it merges with the valley of Cayuga Lake. Southwest of Waterloo, another but much smaller buried valley is indicated by the contour map. This valley lies approximately beneath the course of Kendig Creek.

Unconsolidated Deposits

The unconsolidated deposits of Seneca County, in general, are more porous and more permeable than the consolidated deposits. However, the thickness and physical characteristics of the unconsolidated deposits have an important bearing on the yield that may be expected and the selection of the type of well used to tap the deposits. A comparison of the rock contours (pl. 4) with the land surface (pl. 1) shows that the thickest deposits of Pleistocene age are mainly in the northern third of Seneca County, particularly in the buried-valley areas. In the remainder of the County, the glacial drift, particularly along the upland divide, is relatively thin. The thickness of the glacial deposits increases along the slopes near the Finger Lakes and in the lowlands and valleys. A series of elongated hills trending north-south lies in the north-central region of the County. The hills are drumlins and are composed largely of till, a heterogeneous mixture of icelaid material ranging

in size from particles of clay to coarse gravel and boulders. The coarser grains of the till consist chiefly of limestone, shale, and sandstone fragments derived from the bedrock of Seneca County and nearby areas. In addition, the till contains some igneous-rock fragments that were derived probably from the Adirondack region. Because of its wider range in grain size and lack of stratification, till has a considerably lower permeability than that of outwash sand or gravel, which was deposited from running water. Despite its low permeability, the till, where of sufficient thickness, is generally able to yield small but perennial supplies of water. Occasional lenses of gravel or sand that are covered by glacial lake silts and clays are found between the drumlins in the southern part of the belt. The yield from wells penetrating such lenses may be considerably higher than that from wells penetrating the till.

West of the belt of drumlins is a region of kames and kettles underlain by outwash material deposited by glacial meltwaters. These deposits consist largely of sorted sand and gravel that show varying degrees of coarseness and cross bedding. Figure 4 shows a cross section of an outwash

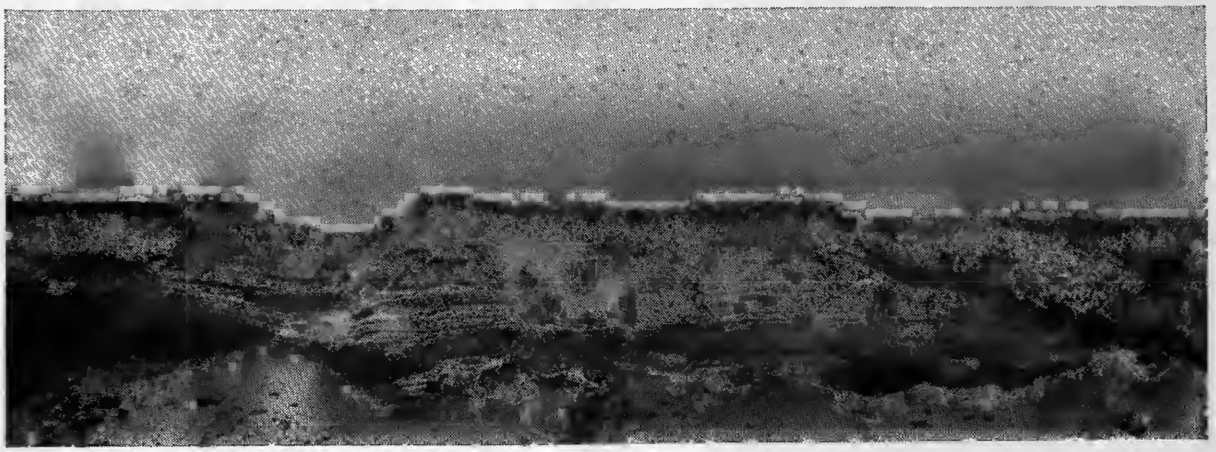

Figure 4.—View of stratified sand and gravel in the kame and kettle region, near Philips Pond, West Junius, N. Y.

deposit as may be seen in one of the gravel pits in the vicinity of Philips Pond just east of West Junius. The gravel layers contain numerous pebbles of limestone, a rock that is slightly soluble in water, thus accounting for the hardness of the ground water in the area. The gravel beds in places are partly cemented. Because of their high permeability the sand and gravel in the kame-and-kettle area absorb precipitation more rapidly than do the till or the glacial lake deposits.

East of the belt of drumlins is the Montezuma Marsh, which occupies an area that roughly marks the position of the buried northern extension of Cayuga Lake valley. A series of shallow test borings made by the New York State Department of Public Works at Montezuma Marsh revealed a layer of muck 4 to 8 feet thick underlain by a layer of marl 2 to 10 feet thick. The marl in turn is underlain by thin layers of sand, silt, and clay. There are no deep test borings in this area, but a well (Se 98) drilled for the Montezuma Migratory Bird Refuge indicated a mantle of drift 135 feet thick underlain by the Camillus shale member of the Salina formation.

South of the drumlin belt, the kame-and-kettle area, and the Montezuma Marsh is a glacial-lake plain. This is a flat-lying lowland belt extending eastward across Seneca County and along the northern end of the west slope of Cayuga Lake. The lake plain is about 5 miles wide and extends along the Seneca River. The deposits beneath the lake plain consist largely of light-colored silt and clay that have a low permeability. The drainage pattern in the area is poorly developed and this, coupled with the relatively low permeability of the deposits, makes it necessary to drain fields under cultivation to dispose of the excess water immediately after periods of prolonged rainfall.

In the western part of the lake-plain area, in the vicinity of the buried Seneca Lake valley, the beds of silt and clay are underlain by coarser materials (see logs of wells Se 123, 191, 194, 107, and 198). The sand and gravel is highly permeable but it is probable that the recharge area of these beds lies to the north, in the kame-and-kettle district, because the overlying silt and clay is relatively impermeable.

South of the glacial-lake plain the surficial deposits are largely till rich in fragments derived from the underlying shale and flagstone. The till forms a thin mantle on the upland divide, where it is generally less than 20 feet thick. Many of the wells in this area are shallow dug wells which, because of their large diameter, afford a greater area for inflow of water than do the drilled wells. In areas where the till cover is thin, dug wells often fail during the summer, when the water table declines below the bottom of the well. Many of the dug wells in the till areas of Seneca County reach bedrock and some are extended for several feet into the rock.

Both east and west of the divide between Cayuga Lake and Seneca Lake the till increases in thickness as the Finger Lakes are approached. The drift is nowhere of great thickness and generally is from 20 to 60 feet thick. The thicker accumulations of drift usually are associated with preglacial valleys and troughs that extend east or west of the divide. Near the lakes the till grades into beds of sand, silt, and clay of lacustrine origin. The presence of water-bearing sands along the shores of the lakes has resulted in the extensive use of driven wells. Some of the test borings made in connection with the construction of the New York State Barge Canal penetrated layers of coarse water-bearing material. Several of the borings along the west shore of Cayuga Lake yielded water by artesian flow, the yields ranging from ½ to 2 gallons per minute.

MOVEMENT AND STORAGE

Wells that obtain water from aquifers not separated from the water table by relatively impermeable beds—that is, aquifers having a water table—are termed water-table wells. Many of the deeper wells encounter water in a completely saturated bed in which water is confined beneath an impermeable layer, so that the water is under sufficient pressure to rise to a level above the bottom of the confining bed (fig. 5). These wells are called artesian wells whether or not the water flows at the surface. The hydrologic properties of water-table and artesian aquifers differ importantly, so that their recognition is essential.

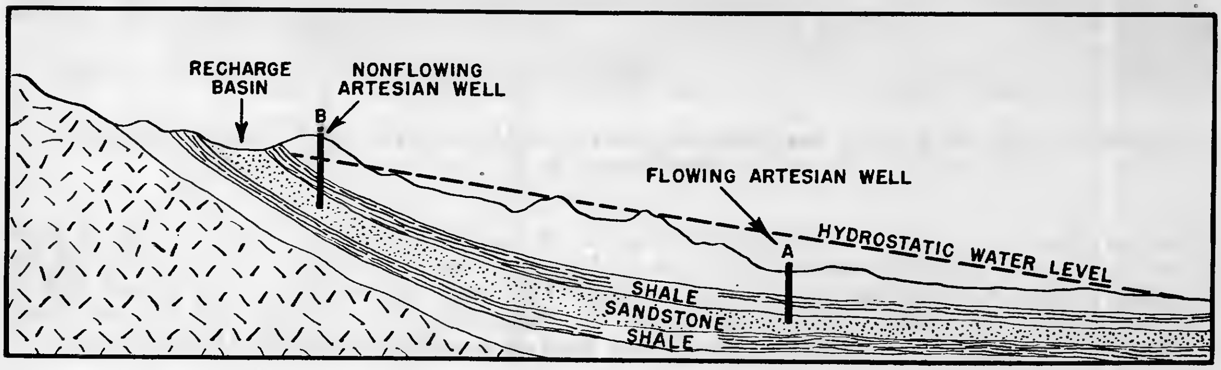

Figure 5.—Diagrammatic section of an artesian basin.

Water-bearing materials rarely are perfectly homogeneous but generally they occur in layers of differing permeabilities. Many beds are not continuous, but thin laterally or are replaced by materials of a different character. Thus, local impermeable beds of limited extent may occur in the zone of aeration, and a body of ground water may be "perched" on such a local layer, below which are unsaturated permeable materials above the main or regional water table. The upper surface of such a perched body of subterranean water is called a perched water table.

The configuration of the water table conforms roughly to the configuration of the land surface. As a result, the water table is an undulating surface that is higher beneath hills than it is in the valleys. Because of the difference in hydrostatic head between the ridges, called ground-water divides, and the troughs, ground water moves continuously from hilly areas toward valleys, where it is discharged at the land surface through seeps or springs. This continuous discharge of ground water is the source of most of the dry-weather flow of streams.

In most areas, precipitation that reaches and moves through a water-table bed is discharged locally after traveling only a relatively short distance beneath the surface of the earth. However, water that percolates into a bed that passes beneath a confining bed, thus becoming an artesian aquifer, may travel many miles beneath the confining bed before being discharged at the land surface.

Because of this, the piezometric surface of an artesian aquifer (the imaginary surface that represents the pressure head and which is analogous to the water table of an unconfined aquifer) may resemble only vaguely the configuration of the land surface.

Artesian conditions are found on a small scale in Seneca County in both the consolidated and unconsolidated sediments. The formations in which are most of the artesian wells whose records have been obtained are the Onondaga limestone and the underlying formations of Silurian age. These rocks crop out in the northern part of Seneca County and dip in a southerly direction. Wells in bedrock that flow are found principally in the area just north of the Seneca River, where the hydrostatic pressure is sufficient to raise the water above the land surface. The flow from most of the wells is small and from many of them ceases entirely during dry periods. There are several deep wells near Cosad which were originally drilled into rocks of the sequence known collectively as the Medina group of various authors (hereafter, in this report, the "so-called Medina group") in search of gas and were then abandoned, owing to lack of sufficient production. The well casings were removed, thereby uncovering one or more artesian aquifers and resulting in flowing water wells. One of these wells, Se 19, has an estimated flow of 100 gallons per minute. The identification of the artesian aquifers is not certain.

RECOVERY

A minimum of about 3.5 million gallons of ground water is recovered daily from wells and springs in Seneca County. A large part of the water is extracted from wells but about 1 million gallons per day is recovered from three large springs.

Springs

A spring may be defined as a natural discharge of ground water from a single or multiple opening. Where no opening is sharply defined, but a discharge of ground water is taking place over a large or indefinite area, the term seep is used. The discharge may be continuous (perennial flow) or interrupted (intermittent flow). The majority of the springs in Seneca County are perennial. Table 4 shows the records of selected springs in the County, the yield of which ranges from half a gallon to 605 gallons per minute. The flow of the smaller springs fluctuates noticeably with the season, and in periods of prolonged drought even the larger springs decline in yield. The springs in the area south of the Seneca River are most common along the steeper slopes leading to the Finger Lakes, and along many of the slopes of the gorges and ravines that drain into the lake. Most of the springs issuing from unconsolidated deposits are seepage springs at the contact between bedrock and overlying mantle.

Spring flow from bedrock is mainly from single or multiple openings in formations having defined bedding planes, fractures, or joints. North of the Seneca River the springs are principally in the unconsolidated materials of the belt of drumlins where in places the slope is interesected by a permeable zone resting on materials of lower permeability, thus causing percolating water to discharge at the surface. The largest flow from a spring in Seneca County is that at Canoga Spring (see table 4), near the settlement of the same name. The measured yield in August 1947 was 600 gallons per minute or 864,000 gallons per day.

Wells

Ground water is recovered principally from wells which may be either dug, bored, jetted, driven, or drilled. The type of well used is dependent upon such factors as depth to the aquifer, lithologic properties of the aquifer and the overlying materials, desired yield, and desired speed and cost of construction. Of the five general types of wells, the first four are used in unconsolidated deposits at relatively shallow depths. The drilled well is best suited for consolidated deposits or where the water-bearing formations are comparatively deep.

As the term suggests, a dug well is a pit that has been excavated to a depth below the water table. If hard materials, such as bedrock, hardpan, or large boulders, are encountered, blasting may be required. For extremely large wells, mechanical digging equipment may be employed. Dug wells are generally lined with field stone, brick, or tile. Most dug wells are in rural areas where the demand for water is largely for domestic or farm purposes; such wells generally range from 18 to 48 inches in diameter. Because of its large area of infiltration, a dug well is capable of supplying small quantities of water from materials of very low permeability. In addition, the dug well furnishes comparatively large reservoir facilities; its diameter is determined largely by the amount of

Table 4.—Records of selected springs in Seneca County, N. Y.

Location: For explanation see section "Methods of investigation." Altitude above sea level: Approximate altitude from topographic map. Use: Dom, domestic; PWS, public water supply.

Spring number	Location	Owner	Altitude above sea level (feet)	Topography	Geologic formation	Yield (gallons per minute)	Temperature (° F.)	Use	Remarks
Se 1Sp	9M, 2.7S, 9.0W	K. Donnely	500	Hillside	Pleistocene till	12	..	Farm	Improved with cement and tile. Equipped with windmill pump. Supply dependable for house and 100 head of stock.
Se 2Sp	9M, 7.8S, 4.7W	P. Ashbrand	460	Lowland	Pleistocene silt and clay	..	54	Dom	Improved with brick. Yield slight but dependable.
Se 3Sp	9M, 9.1S, 4.2W	G. S. Kidd	500	Lowland	Pleistocene silt and clay	..	52	Farm	Equipped with 110-gallon metal tank. Very slight fluctuation. Supply adequate for 25 head of stock.
Se 4Sp	9M, 13.6S, 3.2W	John Trout	650	Hillside	Pleistocene till	..	48	Farm	Improved with cement box. Fluctuation very slight. Contact spring (Pleistocene till-Hamilton group).
Se 5Sp	9M, 10.5S, 0.6W	L. Parker	440	Flatland	Onondaga limestone	605	48	Farm	Improved with cement box. Heavy overflow during wet season Gas bubbles but no odor.[a]
Se 6Sp	9M, 9.9S, 9.6W	G. Dwyer	500	Valley	Pleistocene till	..	45	Farm	Improved and equipped with cement box, pump house, and suction pump. Supply dependable. Furnishes 7 families and 55 head of stock. Water reported hard.
Se 8Sp	10M, 13.8S, 3.4E	D. U. Ditmas	1,070	Valley	Pleistocene till	..	..	Farm	Improved with field stones. Water piped to barn. Supplies 25 to 30 head of stock. Fluctuates with season.
Se 9Sp	10M, 13.1S, 3.3E	C. W. Bates	1,020	Hillside	Pleistocene till	..	52	Farm	Improved with cement box.
Se 10Sp	10M, 8.6S, 0.7E	J. B. Usher	900	Valley	Pleistocene till	..	..	Farm	Yield very low at time of observation, October 1947.
Se 11Sp	10M, 10.4S, 5.3W	Dr. R. Faee	820	Hillside	Pleistocene till	..	54	Dom	Improved with round cement box approximately 10 feet in diameter. Reported dependable.
Se 12Sp	9M, 14.6S, 1.2W	E. R. Smith	460	Valley	Pleistocene till	..	..	Farm	Improved with field stone basin 4 feet in diameter. Supplies 20 head of stock but is reported to fail.
Se 14Sp	10M, 6.6N, 0.6E	R. Gibbs	400	Hillside	Oriskany sandstone and Manlius limestone	34	50	Dom	Improved with field stone and wooden weir.[a]
Se 15Sp	9M, 0.2S, 8.7W	George Lash	470	Hillside	Pleistocene till	3	49	Farm	Two springs in area. One improved with tile; other improved by concrete box and piped by gravity to public drinking fountain.
Se 16Sp	9M, 3.5S, 0.8W	Harry Hothnagel	440	Hillside	Pleistocene till	1	54	None	Roadside spring. Improved with concrete.
Se 17Sp	10M, 10.2S, 6.4W	..	460	Hillside	Pleistocene till	0.5	50	None	Roadside spring. Improved with 1-inch pipe driven horizontally into hillside and sheltered with concrete box. Other small springs in area.
Se 18Sp	10M, 6.8S, 6.2W	Walter Lyons	500	Ravine	Tully limestone	3	49.5	None	Not used; reported dependable. Iron precipitate deposited about spring.
Se 19Sp	10M. 9.8S, 0.2E	Village of Interlaken	1,100	Ravine	Pleistocene till	..	..	PWS	Seepage springs improved by tile collecting basins, total capacity 150,000 gallons. Average consumption 35,000 gallons per day. Yield decreases during dry seasons.
Se 20Sp	10M, 6.8N, 0.7E	W. C. Burgess	380	Lowland	Pleistocene sand	8	50	Dom	Improved with concrete. Reported steady flow.

[a] For chemical analysis see table 5.

storage required. Dug wells are subject to failure, however, during prolonged periods of drought when the water table declines below the bottom of the well. Other disadvantages of the dug well are the danger of contamination by polluted surface water and shallow soil drainage. Approximately two-thirds of the wells ending in the unconsolidated deposits of Seneca County are dug wells.

A bored well is constructed with an auger that may be either hand- or power-operated, and upon completion the hole is cased. Such a well may be used if the water-bearing formations are permeable and at a shallow depth. The amount of water that can be pumped from the well is limited by the diameter of the open end of the well casing. In recent years there has been an increase in the diameter of the boring tools manufactured. Advantages of this type of well construction are the economy of materials and labor costs, and the speed of construction.

The only records of bored wells in Seneca County are for the test borings made in connection with the construction of the New York State Barge Canal.

A jetted well may be constructed under conditions where the waterbearing formations are not far below the surface and are free of very coarse materials or boulders, which may impede or even prevent the setting of the casing. This type of well can be quickly and economically installed without the use of heavy and costly equipment. A well is jetted by washing a casing vertically into the overburden by means of a jetting pipe that is lowered into the casing, until the water table is intersected. A well pipe of smaller diameter with an attached screen at its lower end is placed within the casing, and the outer casing then is withdrawn. This leaves the well pipe and screen in position, ready for pumping. No jetted wells in Seneca County were found in connection with the inventory for this report.

A driven well is best adapted to areas where the water table lies near the surface and the earth materials are free from large fragments and boulders. It is constructed by driving a pointed screen called a drive point, attached to a sufficient length of well pipe, into the water-bearing formation. The pipe is driven into the ground with a sledge hammer or by a mechanized drop-hammer. There are many driven wells in Seneca County, especially along the shores of Cayuga Lake and Seneca Lake where there are extensive beds of sand and gravel.

Drilled wells are the most important and most widely used wells in Seneca County. This type of well may be constructed by either the "cable-tool" or the "hydraulic-rotary" method. The former is a percussion technique in which a chisel-like drill bit is repeatedly raised and dropped, thereby crushing the formation being drilled. The resulting pulverized debris or sludge is periodically withdrawn from the hole by means of a bailer, a long, narrow bucket having a flap valve in the bottom. In drilling by the percussion method, the driller may employ one of two techniques. He may either "drill and drive" or "drive and then drill" the plug. The first technique involves drilling ahead of the casing; that is to say, the hole is drilled ahead for a few feet and then the casing is driven. By the other method, the driller drives the casing into the ground as far as possible and then drills and bails out the plug of earth within the casing. The latter method of percussion drilling is not possible in consolidated rocks, and even in unconsolidated rocks it may result in stripped casing threads, in telescoped casing, or in missing possible water-bearing formations.

The hydraulic-rotary method of drilling in the eastern part of the United States employs rotating tools that are attached to the bottom of a string of drilling pipe. "Drilling mud," a thin slurry of clay or of specially prepared fine-grained material, is pumped down the hollow rotating drill rod, out through the drill bit attached to the lower end of the pipe, and back to the land surface through the annular space between the drill rod and the walls of the hole. The mud serves a dual purpose; as it returns to the surface it carries along the drill cuttings from the hole, and by virtue of its hydrostatic pressure it prevents caving of the walls of the well. Generally the well casing (including screens if required) is lowered and set into place in one continuous operation after the well has been drilled to the required depth.

Drilled wells in unconsolidated materials may or may not be finished with a screen. The installation of a screen opposite the aquifer increases the area of infiltration and allows a greater yield. Wells in which screens are not installed draw water only through the open end at the bottom of the casing. Such wells may easily be plugged up by silt or sand drawn in through the open bottom. When a well is drilled into solid rock the hole is left uncased unless it penetrates highly fractured or incompetent formations that are likely to cave in. To prevent caving, the driller may set casing at the troublesome levels. Most of the wells in Seneca County for which records were obtained were drilled by the cable-tool method, particularly in those areas where the bedrock is covered by only a thin mantle of drift.

Distribution of Wells

Of the 307 selected wells listed in table 7, 108 end in unconsolidated deposits and 199 bedrock. The number of records collected was considerably larger, but only the more complete records were selected for tabulation, on the basis of such data as depth of the well, yield, and depth to the water level.

Nearly two-thirds of the wells in rock are in that part of Seneca County lying south of the outcrop area of the Onondaga limestone (pl. 2), and hence they tap the Marcellus shale or younger formations. The remainder of the rock wells were drilled into the Onondaga and older formations and are in the lake-plain area or the area of Pleistocene till to the north. Conversely, approximately two-thirds of the wells ending in unconsolidated deposits are in the lake-plain area and the region to the north. The remaining third of the wells are scattered chiefly along the hill slopes near Cayuga Lake and Seneca Lake. The boundary separating the glacial-lake plain from the till plain to the south is also the boundary separating the area in which rock wells predominate from the area in which wells tapping unconsolidated deposits predominate. This marked division reflects the distribution and the thickness of the Pleistocene deposits in the County.

Consolidated Rocks

Records of 280 wells penetrating rock in Seneca County were collected. Of these, 273 were drilled and only 7 were dug. The maximum recorded depth is 1,600 feet, and the average depth is 112 feet. The average depth at which the water table was encountered is 22 feet, and the mean yield of the wells is approximately 18.5 gallons per minute. The three deepest wells in the County (Se 18, 19, and 234) are 1,400 to 1,600 feet deep, and probably end in the so-called Medina group. These wells originally were drilled for natural gas, but as the yield was insufficient for commercial development they later were abandoned. Although drilled more than a score of years ago, one well, Se 18, still supplies gas for domestic cooking and heating. The other two wells, Se 19 and 234, are now flowing water wells, well Se 19 flowing at the approximate rate of 100 gallons per minute.

Salina formation.—Of 42 wells reported in the Salina formation 41 were drilled and 1 was dug. The diameter of the drilled wells ranged from 4½ to 10 inches, but 6 inches was the most common. The average depth of the wells was 160 feet, and the range in depth was from 22 to 800 feet. In the area where the Salina formation lies directly below the drift, it was encountered at depths between 4 and 140 feet. The water level was reported at 5 to 100 feet below the land surface, the average being 27 feet. Yields reported from the Salina formation ranged from 5 to 400 gallons per minute, the average yield being 45 gallons per minute.

Water from deep wells in the Salina formation may be mineralized and be high in either chloride or sulfate, or both, often having a distinct taste or odor. Well Se 211, drilled to a depth of 787 feet, yields water containing small flakes of gypsum. When well Se 98 was drilled at the Montezuma Migratory Bird Refuge, salt water was reported at two horizons in the drift and at five horizons in bedrock. Analyses of four samples of water obtained from the Salina formation show the dissolved solids to range from 877 to 2,190 parts per million with an average of 1,480 parts per million. This is considerably above the generally recognized limit of 500 to 1,000 parts per million. The average hardness is 865 parts per million, which definitely is far above the tolerable level (150 parts per million is considered high). The noncarbonate hardness is greater than the carbonate hardness in three of the samples tested. The maximum chloride content reported was 74 parts per million. The shallow wells in the Salina formation are more likely to have a carbonate hardness in excess of the noncarbonate than are the deeper wells. This may be due to the greater amount of leaching of the sulfates at shallow depths which has resulted from a more active ground-water circulation.

Cobleskill dolomite and Rondout and Manlius limestones.—The Cobleskill dolomite and the Rondout and Manlius limestones are only about 25 feet thick and may be considered a single aquifer. Only six wells were reported as ending in these formations. All the wells are 6 inches in diameter; their average depth is 95 feet. Bedrock was encountered at depths between 5 and 46 feet beneath the land surface. Reported yields ranged from 4 to 30 gallons per minute, the average being 14 gallons per minute.

An analysis of water from well Se 503 showed a total hardness of 1,000 parts per million. The noncarbonate or "permanent" hardness was in excess of the carbonate or "temporary" hardness. The dissolved-solids content was high, being 1,842 parts per million. It is possible that water may be rising under artesian pressure from the underlying Salina formation.

Oriskany sandstone.—The Oriskany sandstone is absent in the northern part of Seneca County, and has not been recognized in the southern part of the County either at outcrops or in well cuttings.

Onondaga limestone.—On the basis of the yield of existing wells, the Onondaga limestone is second in importance only to the Salina formation as a bedrock aquifer in Seneca County. Reported yields from 42 wells range from 1 to 200 gallons per minute and average 33 gallons per minute. The depth of wells in the Onondaga ranges from 40 to 465 feet and averages 112 feet. Of the wells tapping the Onondaga limestone those within its area of outcrop have the largest yields reported, especially in areas where the surficial cover of glacial drift is thin and where the outcrop is traversed by streams. These factors, together with the relatively flat topography, permit favorable conditions of recharge to the limestone. One factor affecting the amount and rate of recharge is the kind of material covering the limestone. Where it is overlain by permeable outwash, yields are comparatively high. The lacustrine silts and clays are very porous but are also comparatively impermeable and therefore retard the rate of downward seepage of precipitation and subsurface waters, thus resulting in lower yields from the underlying bedrock. However, this disadvantage may be compensated by the flat topography in the area of outcrop of the Onondaga limestone. Wells reaching the limestone in areas where it is overlain directly by shale generally have lower yields.

Yields from the limestone formations decrease to the south in proportion to the distance from their area of outcrop. This is explained by the fact that the effect of solution on the limestone is less marked in those areas overlain by less permeable materials, which retard the rate of subsurface-water circulation and of downward percolation. Where the Onondaga limestone is overlain by beds of younger shale the effect upon yield can readily be noted. Well Se 138 is 465 feet deep and has a reported yield of 1 gallon per minute, whereas well Se 227 is 230 feet deep and has a yield of 5 gallons per minute. The largest yield is from a 75-foot well in Waterloo, which is pumped at a rate of 200 gallons per minute.

A slight sulfur odor or taste may be present in the water from the Onondaga limestone. Analyses of five samples show an average hardness of 317 parts per million, and the carbonate hardness generally exceeds the noncarbonate hardness. This change in the type of hardness in water withdrawn from the Onondaga limestone suggests that the Onondaga marks the upper limit of the occurrence of excessive noncarbonate hardness in the ground water of Seneca County. The dissolved solids average 557 parts per million.

Hamilton group.—Most of the rock wells in Seneca County tap rocks of the Hamilton group. Of the 81 wells tapping the Hamilton group 78 are drilled wells, most of them 6 inches in diameter. Yields range from ¼ gallon to 60 gallons per minute and the average yield of all wells ending in the Hamilton group is 11 gallons per minute. The yield of a well ending in the Hamilton group is dependent largely upon the amount of fracturing and preglacial weathering. However, there is no noticeable direct correlation between yield and depth. The average depth of the wells is 105 feet and they range in depth from 18 to 665 feet. Water levels range from 3 to 170 feet below the land surface. Wells tapping the Hamilton group are subject to periodic failure in time of drought, particularly in areas of high altitude.

As indicated by four analyses (see table 5, wells Se 202, 256, 271, and 285), water from the Hamilton group contains less dissolved solids and is softer than that from the older formations. Dissolved solids average 519 parts per million and range from 384 to 788 parts per million. The average hardness is 393 parts and the carbonate hardness definitely is in excess of the noncarbonate hardness. The content of iron in water extracted from the Hamilton group averages 3.63 parts per million and is considerably higher than that in water derived from the older rocks. The higher content of iron is due probably to the nodules of iron sulfide that are conspicuously present in the beds of shales in the lower part of the Hamilton group. An analysis of a sample of water from well Se 285 showed the presence of 12 parts per million of iron and 0.25 part per million of manganese. The average chloride content of waters from the Hamilton group was 7.5 parts per million. This is less than the average chloride content of water from the older formations.

Tully limestone.—The Tully limestone is not here discussed separately because its hydrologic properties are similar to those of the Hamilton group.

Genesee group.—The beds of shale in the Genesee group crop out as a narrow, V-shaped band whose apex points north. The narrowness of the area of outcrop accounts, in part, for the small number of wells ending in the Genesee group. Records were obtained of only 18 wells tapping the Genesee group. All the wells are drilled wells 6 inches in diameter and they range in depth from 20 to 175 feet. The rocks of the Genesee group have low permeability and recharge is small because of the steep slope of the land surface, the high altitude, and the narrowness of the area of

outcrop. In addition, recharge from percolating water in the overlying drift is not great, for the drift is thin and hence not capable of storing large quantities of water. The yield of wells in the Genesee group ranges from 1/5 gallon to 20 gallons per minute and averages 7 gallons per minute. The group was encountered at depths ranging from 4 to 38 feet below land surface, and averaging 11 feet.

Analyses of two water samples from wells in the Genesee group (Se 308 and 333) indicate that the dissolved solids average 448 parts per million and the total hardness 372 parts per million. The carbonate hardness of the sample from well Se 308 exceeds the noncarbonate hardness, and in the sample from well Se 333 the two were approximately the same. However, in the latter analysis the noncarbonate hardness reported is not caused by the presence of sulfates. The chloride content of the samples analyzed is low and the iron and manganese concentrations are slightly above desirable amounts.

Cashaqua and Hatch shales.—The Cashaqua and Hatch shales are composed of a thick sequence of alternating beds of shale and flagstone and underlie a large part of the upland area in Seneca County. The effect of increased altitude is reflected by the number of wells that have been reported to fail during periods of prolonged drought or by continuous or excessive pumping. Of 78 wells ending in the Cashaqua and Hatch shales 75 are drilled wells, 6 inches in diameter, and 3 are large-diameter dug wells about 20 feet deep. The drilled wells range in depth from 20 to 368 feet and average 78 feet. Yields reported were from 1/4 gallon to 50 gallons per minute and the average was of 6½ gallons per minute, or slightly less than the average yield reported for 18 wells tapping the Genesee group. Several of the wells in the Cashaqua and Hatch were reported to have small artesian flows.

Analyses of three water samples withdrawn from wells tapping the Cashaqua and Hatch shales show an average of 494 parts per million of dissolved solids and a total hardness averaging 373 parts per million. The carbonate hardness is in excess of the noncarbonate hardness. Excessive iron content and sulfur taste and odor are commonly reported for well water derived from these rocks.

Grimes, West Hill, Nunda, and Wiscoy formations.—The Grimes, West Hill, Nunda, and Wiscoy formations underlie the upland plateau area in the southernmost part of Seneca County. Much of this region is utilized as pasture land and extremely variable rainfall has made crop farming a risky enterprise. Records of 10 wells that tap the Grimes-Wiscoy sequence show depths ranging from 45 to 265 feet, the average depth being 91 feet. The average depth to water is 17 feet. The yields reported range from 1.5 to 12 gallons per minute and average 5 gallons per minute. The yield from wells in the Grimes-Wiscoy sequence is less than that of wells tapping older rocks.

Three analyses of water in the Grimes-Wiscoy sequence (wells Se 343, 362, and 370) show a maximum hardness of 350 parts per million. In each sample the hardness was due to the presence of bicarbonate and not sulfate. The dissolved solids ranged from 292 to 474 parts per million—the lowest content of dissolved solids encountered in ground water from the consolidated rocks in Seneca County.

Unconsolidated Rocks

Of 154 wells reported to tap the unconsolidated rocks in Seneca County, 106 are dug, 46 are drilled, and 2 are driven wells. The deepest of the dug wells is 55 feet, but approximately 90 percent of these wells are less than 30 feet deep. Diameters range from 18 to 48 inches, but most of them are 36 inches. Drilled wells range in depth from 9 to 268 feet. The majority are 6 inches in diameter, but some are as much as 12 inches in diameter. The driven wells tap the soft lake sediments adjacent to the Finger Lakes. They are all less than 2 inches in diameter and are driven into water-bearing beds less than 20 feet deep.

Yields from wells in the unconsolidated rocks range from less than ½ gallon to 230 gallons per minute and average 17 gallons per minute. The wide range in the permeability of the glacial deposits is indicated by the wide range in reported yields. Approximately two-thirds of the wells drilled in the unconsolidated rocks are in the northern third of Seneca County. This part of the County embraces the belt of drumlins, the outwash sands and gravels of the kame-and-kettle region, the glacial-lake plain, and the Montezuma Marsh. The remaining wells tapping the unconsolidated deposits are in the southern part of the County which includes the glacial-till plain and the upland plateau section.

Glacial-lake plain.—The glacial-lake plain contains the largest number of the wells that end in unconsolidated Pleistocene deposits. Of a total of 66 wells, 33 are dug, 31 drilled, and 2 driven. The yields reported range from 3 to 230 gallons per minute and average about 15 gallons per minute.

The largest yields of wells tapping unconsolidated deposits are from two test wells, Se 194 and 195, in the western part of the glacial-lake plain just south of the kame-and-kettle area. The two test wells penetrate 202 and 175 feet, respectively, of sand and gravel that were deposited in the buried northward extension of Seneca Lake valley. The yields were 225 and 230 gallons per minute, respectively, after 3-hour pumping tests. These test wells and several others were made in an attempt to secure an adequate ground-water supply for the village of Waterloo. Wells Se 126, 180, and 198, which yield 75, 50, and 65 gallons per minute, respectively, are also in this buried valley.

An analysis of a sample of water taken from well Se 126 indicates a chloride content of 1,000 parts per million. This is probably due to the infiltration of mineralized water from the underlying Salina formation. Water samples from 10 wells reveal a range in dissolved solids from 389 to 4,448 parts per million. The total hardness ranges from 20 to 1,900 parts per million. The noncarbonate hardness exceeds the carbonate hardness in about half the analyses. Wells drilled deep into the sand or gravel in preglacial-valley areas may have a high content of sulfate and chloride. The analyses showed as much as 15 parts per million of iron.

Drumlin belt.—Records were obtained of 31 wells in the belt of drumlins. Of the total, 24 are of dug wells and 7 are of drilled wells. The dug wells have a maximum depth of 55 feet, and the drilled wells a maximum depth of 100 feet. Water levels range from 10 to 30 feet below the land surface. Yields range from 1 to 60 gallons per minute, but most of the wells yield from 5 to 10 gallons per minute.

Analyses of two water samples (Se 39, 44) obtained in this area indicate that the dissolved solids are low in comparison to those of the ground-water samples obtained in the glacial-lake plain. The hardness is from 230 to 480 parts per million and the carbonate hardness exceeds the noncarbonate hardness. It is quite probable that deeper wells in the drift may show an increase in the amount of sulfate. If so, this would indicate that the sulfate has been leached out of the upper part of the drift. The iron and chloride contents are low in comparison to those of water pumped from wells in the lake-plain area.

Kame-and-kettle area.—Only four well records were obtained in the kame-and-kettle area. Three of the four wells have a yield of 5 gallons per minute and the fourth has a yield of 30 gallons per minute. Analysis of a water sample taken from well Se 34, drilled to a depth of 62 feet, indicated a total hardness of 340 parts per million, the carbonate hardness being in excess of the noncarbonate hardness. Analysis of a water sample from well Se 119, drilled to a depth of 178 feet, showed a dissolved-solids content of 2,252 parts per million and a total hardness of 1,300 parts per million. The noncarbonate hardness, however, greatly exceeded the carbonate hardness. The beds of sand and gravel of the kame-and-kettle area contain many particles derived from the underlying Salina formation and the limestone and shale that crop out north of Seneca County. This would account for the excessive hardness of the ground water in this area.

Till-plain area.—Records were obtained of 15 dug wells and 2 drilled wells in the till-plain area. Most of the dug wells range from 20 to 30 feet in depth and are 36 inches in diameter. Bedrock was encountered in the dug wells at depths ranging from 6 to 28 feet below the land surface. The drilled wells in this area are, on the average, about 30 feet deeper than the dug wells. The yield of all wells ranges from 2 to 20 gallons per minute, the average being approximately 8 gallons per minute. Well failures caused by a lowering of the water table during periods of drought are common in this area.

A single analysis (Se 252) shows the hardness of the water to be more than the maximum acceptable, and the carbonate hardness in excess of the noncarbonate hardness. The dissolved-solids content is 909 parts per million.

Upland plateau area.—The upland plateau area, lying in the southernmost part of Seneca County, is the highest of the agricultural regions in the County. The overburden consists of a thin mantle of till, from 2 to 30 feet thick. Of the 34 well records obtained in the area, 29 are of dug wells and 4 of drilled wells. Most of the dug wells are from 10 to 30 feet deep and range in diameter from 30 to 36 inches. The drilled wells are slightly deeper and range in diameter from 6 to 12 inches. In all but two wells, the yield ranges from 2 to 6 gallons per minute, and the average is about 5 gallons per minute. In this area also the average yield of wells decreases with an increase in altitude. Two of the wells, Se 337 and 338, have relatively high yields, 20 and 200 gallons per minute, respectively. Well Se 337 supplies water for drinking and sanitary use at Ovid Central School. Well Se 338 is one of two wells that provide water for the Ovid municipal supply. Well Se 338 is only 20 feet deep and is near the Ovid Central School well. Its high yield is an example of

what can be accomplished through proper well development. The well is finished with a screen 5 feet long and 12 inches in diameter that is surrounded by an artificial gravel pack 6 inches thick.

Analyses of three water samples obtained from unconsolidated rocks in the upland plateau section show a range in dissolved solids from 348 to 420 parts per million. The total hardness of the water averages 230 parts per million, and in each sample the carbonate hardness was in excess of the noncarbonate hardness.

UTILIZATION

Of the wells that have been investigated in Seneca County 87 percent are used mainly for household or farm purposes. Of the remaining wells 8 percent are not used, 3 percent are used for commercial purposes, and 2 percent are used for industrial production, irrigation, or public supply. The wells that are not used include 11 that were abandoned because of insufficient yield or excessive hardness of the water. Other wells have been abandoned because of the taste and odor of the water, which usually was caused by a high content of chloride, sulfate, iron, or suspended solids. Of the springs examined, the majority were used for household or farm supply. One of the springs is the source of water for the public-supply system of Interlaken.

Domestic Supplies

Four of the largest communities in Seneca County are served by public water-supply systems. The people in the other communities of the County are dependent wholly upon individually owned wells. Wells used for domestic supply, though of low yield, generally furnish an adequate amount of water for normal cooking, drinking, laundering, and sanitary needs. On a farm stocked with only a few animals, one well may be adequate for both farm and household needs, but on heavily stocked farms an additional well generally is needed to meet the greater demand for water. Average daily withdrawal from domestic wells probably has not exceeded 500 gallons per day each.

Commercial Supplies

Only a few wells in Seneca County furnish water for commercial establishments. The principal commercial stores are in the larger villages and along the more important highways. The business establishments in the four largest villages utilize local public-supply systems, but those not within village limits are dependent upon wells for water. Only 13 wells used for commercial purposes are listed in table 7. They are at automobile-service stations, garages, restaurants, and tourist cabins. At most of these establishments, withdrawals are not much greater than those normally required from household wells. The range in yield is from 5 to 60 gallons per minute and the greatest consumption is 10,000 gallons per day, at a group of tourist cabins. For all wells the average daily pumpage is 750 gallons.

Irrigation Supplies

Only one of the wells investigated in Seneca County, well Se 207, is used for irrigation. The water is used for seed-potato cultivation. Its yield is 60 gallons per minute and during dry periods the well has been pumped continuously at that rate for as long as 3 weeks, with no sign of depletion.

Industrial Supplies

Most of the industries in Seneca County are in the villages of Waterloo and Seneca Falls, which are on the principal routes of transportation in the County. The industries are served by the public water-supply systems of Waterloo and Seneca Falls, and hence have no need for private supplies except where the low temperature of ground water is desired for cooling and air conditioning. One food-processing plant in the village of Waterloo supplements the water it receives from the municipal supply by pumping water from well Se 512, which has a reported yield of 200 gallons per minute. During the height of the canning season the daily pumpage of ground water from this well has averaged about 300,000 gallons. The water is hard, however, and slightly cloudy and can be used only for washing and cooling purposes. Two other wells at the plant (Se 206 and 511) are capped and remain as emergency sources of water in the event the village supply becomes overtaxed during the summer months. Three other wells in Waterloo, at creameries, furnish from 10,000 to 20,000 gallons per day for cooling and washing. Well Se 504, at a creamery in Interlaken, yields 50 gallons per minute and has been used on several occasions to augment the village water supply during prolonged periods of drought. The total daily consumption from all wells used for industrial purposes in Seneca County probably does not exceed an average of 350,000 gallons.

Public Supplies

Approximately 41 percent of the total population of Seneca County resides in its two largest communities, Seneca Falls and Waterloo. These communities obtain their water supply from Cayuga Lake and the Seneca River, respectively. The villages of Ovid and Interlaken, the next largest communities in Seneca County, depend wholly upon ground water for their public supply. Ovid obtains water from two shallow wells, and Interlaken obtains water from a series of improved seepage springs. The U. S. Army Ordnance Depot at Romulus and the State Hospital at Willard have their own water-supply systems, which utilize surface water.

Seneca Falls.—The water-supply system of the village of Seneca Falls serves a population of 6,472. The filtration plant, constructed in 1941, is approximately 8 miles southeast of Seneca Falls near the shore of Cayuga Lake. Daily consumption has been as great as 650,000 gallons, of which approximately 83 percent is utilized for domestic and commercial purposes, and the rest by industrial establishments. The water is filtered and chlorinated before it is pumped into the distribution system.

Waterloo.—The municipal water system at Waterloo serves about 4,500 inhabitants. Daily consumption averages about 525,000 gallons, of which 75 percent is used by food and textile industries. The water supply is pumped from the heavily polluted Seneca River. On days of peak pumpage or when the river water is polluted very heavily, the public-supply treatment plant is taxed to the limit of its capacity. Because of this situation the village of Waterloo has investigated the possibility of developing a ground-water supply. Fourteen test wells (see table 7 for records of 11 of the wells, Se 188 to 198) were drilled to various depths in an effort to locate an adequate supply, but the project was abandoned because of insufficient yield or because of water hardness that was considerably in excess of the acceptable maximum. The test wells of greatest yield penetrated beds of sand and gravel in the preglacial Seneca Lake Valley. These wells also yielded the hardest waters.

Ovid.—The public water-supply system of Ovid serves 75 percent of the population of 600. Pumping began in July 1938 from a well 8 inches in diameter and 17.5 feet deep. At that time the static water level was 4 feet below land surface. A yield of 320 gallons per minute, with a drawdown of 4 feet, was obtained during a short pumping test. The water supply now is derived from two shallow wells (Se 338), each of which has a yield of 200 gallons per minute. Both wells penetrate a layer of clay about 5 feet thick and then pass through about 13 feet of black gravel. Each is 18 inches in diameter and is finished with 5 feet of screen that is surrounded with an artificial gravel pack. Each well is equipped with a centrifugal pump having a rated capacity of 200 gallons per minute.

In 1947, daily consumption at Ovid averaged 28,000 gallons and was principally for domestic purposes. The well water is not treated and is pumped directly into the distribution system and into the reserve storage tank which has a capacity of 52,000 gallons. An analysis of the well water is given in table 5. During periods of extended drought, the decline of the water table in the vicinity of the public-supply wells causes a serious decline in yield. To offset the shortage, water from well Se 337, at Ovid Central School, is pumped into the village supply system. To avoid the possibility of serious shortages in the future, the village of Ovid is considering the construction of additional wells. Because of the danger of contamination from the many cesspools in the village, it has been decided to limit the area of exploration and well development to the area east of the main north-south highway, which passes through the center of the village.

Interlaken.—The water for the municipal supply at Interlaken is obtained from a seepage-spring area (Se 19Sp) improved by an infiltration gallery consisting of tile pipes 4 inches in diameter, draining into 12 separate concrete catchment basins. The seepage area is approximately 1.5 miles southwest of the village and at an altitude of 1,100 feet. From the concrete basins the water is delivered by gravity directly to the village distribution system and to an elevated standpipe which has a storage capacity of 150,000 gallons. The total combined storage capacity of the catchment basins and the elevated tank is approximately 2 million gallons (New York State Dept. Health, 1948, p. 24). The average daily consumption is 35,000 gallons, the water being used primarily for domestic needs. It is not treated. A chemical analysis of the water is given in table 5. The yield from spring Se 19Sp has been insufficient to supply the town during the dry periods that coincide with peaks of water consumption. Accordingly, the village has taken steps to augment its supply by acquiring well Se 504, which has been privately owned.

QUALITY

Information on the chemical and physical characteristics of water supplies is necessary before plans are made for the location of industries and for economical and satisfactory treatment of water for domestic and industrial consumption. When these properties of the water are known accurately, the most suitable equipment for water treatment, steam-boiler plants, air-conditioning use, etc., can be planned and unnecessary equipment or treatment can be eliminated.

Water samples from a selected number of wells in Seneca County were analyzed for their content of certain dissolved constituents by the New York State Department of Health, and three complete analyses were made by the U. S. Geological Survey in Washington, D. C. These analyses, together with those obtained from private sources, are given in table 5.

The minerals and gases present in ground water are those absorbed or taken into solution by the water as it fell through the air as rain and as it moved through the soil and rock. The variations in the quantity of mineral matter in different waters depends, among other things, upon the chemical composition of the rock materials and the duration of the contact with them, the temperature, the pressure, and the constituents in the water previously dissolved from other rock.

In general, the character and amount of the minerals and gases in water from a given ground-water source remain relatively constant throughout the year, although changes may occur very gradually during longer periods. The composition of water from shallow wells or channels in limestone, however, may fluctuate in accordance with variations in the rate of recharge and discharge. Also, where wells draw water from alluvial aquifers that are recharged to a greater or lesser degree by infiltration from a nearby stream, the chemical composition of the well water may change decidedly with changes in the rate of inflow or in the composition of the river water.

Dissolved Solids

The range of dissolved solids in the analyses given in table 5 is from 292 to 4,450 parts per million. The average for the 41 analyses is 1,020 parts per million. The desirable maximum for most commercial and industrial use is about 500 parts per million, but water having a greater content of dissolved solids may be suitable if the hardness and iron and chloride contents remain low. The dissolved solids in 24 water samples taken from wells ending in bedrock ranged from 292 to 2,670 parts per million and average 872 parts per million. The dissolved solids in 13 of these were less than 500 parts per million. Water samples from 17 wells tapping unconsolidated deposits had a higher content of dissolved solids, ranging from 308 to 4,450 parts per million and averaging 1,220 parts per million. Only six of the analyses showed less than 500 parts per million. The available data indicate that the dissolved solids in water from unconsolidated materials generally is greater than those in water from consolidated rocks. There is also a suggestion that the dissolved solids increase with depth, or at least are greater in wells that tap buried valley deposits. The majority of such wells have a higher sulfate content.

Hardness

Hardness is the characteristic of water that generally receives the most attention in domestic and industrial use of water. It is recognized by the increased quantity of soap required to produce a lather, and by the deposit of insoluble mineral scale in boilers or kettles when hard water is heated or evaporated. Carbonate hardness, or that due to the calcium and magnesium equivalent to the bicarbonate in the water, may be removed almost completely by boiling; but noncarbonate hardness, caused by other compounds of calcium and magnesium, such as chloride or sulfate, cannot be removed by boiling. Both carbonate and noncarbonate hardness affects the use of soap. The noncarbonate hardness is particularly troublesome in steam boilers, producing a harder scale.

Water having a hardness of less than 60 parts per million is considered soft, and it is not profitable to soften such waters artificially except for certain industries that use water approaching that degree of hardness in steam boilers. A hardness of 60 to 120 parts per million does not seriously affect domestic and most industrial use of water, although the consumption of soap is increased somewhat. Softening of municipal supplies is not usually practiced but sometimes water is softened for domestic use. Softening of the water for a laundry is likely to be profitable, and prior softening or treatment within the boiler is generally necessary for a steam-boiler plant. The effect of water having a hardness of 121 to 200 parts per million is noticed by nearly everyone and such water must be softened for use in any industrial process in which hard water is detrimental. Softening of household supplies is desirable, and softening of municipal supplies may be profitable. Water having a hardness greater than 200 parts per million is considered to be very hard and is objection-

Table 5.—Chemical analyses of water from selected wells and springs in Seneca County, N. Y.

(Analyses by New York State Department of Health unless indicated otherwise. Dissolved constituents given in parts per million.)

Well or spring number	Depth (feet)	Geologic formation	Date of collection	Dissolved solids	Silica (SiO_2)	Iron (Fe)	Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium and potassium (Na+K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Hardness (as $CaCO_3$)			pH
																Total	Carbonate	Noncarbonate	
Se 14	16	Pleistocene outwash	6-4-47	439	..	0.4	0.2	..	..	..	303	63	6	..	..	310	248	62	7.2
Se 19	1,600	So-called Medina group	8-26-48	2,670	..	.8	.01	..	..	..	275	1,380	5	..	..	1,520	230	1,290	6.9
Se 32	150	Salina formation	10-23-48	1,020	..	.08	.01	..	..	..	366	103	74	..	..	400	300	100	7.6
Se 34	62	Pleistocene gravel	10-23-48	825	..	.25	.01	..	..	..	383	103	82	..	..	340	314	26	7.5
Se 39	14	Pleistocene deposits	6-6-47	308	..	.15	.01	..	..	..	243	40	2	..	..	230	199	31	7.5
Se 44	39	Pleistocene deposits	10-23-48	768	..	.27	.01	..	..	..	403	103	19	..	..	480	330	150	7.3
Se 61	85	Salina formation	10-23-48	877	..	4.0	.01	..	..	..	290	365	7	..	..	490	238	252	7.5
Se 70	30	Pleistocene deposits	6-11-47	2,541	..	15	.02	..	..	..	221	1,460	3.2	..	..	1,600	180	1,420	7.0
Se 81	147	Salina formation	10-25-48	1,840	..	.25	.01	..	..	..	322	918	5	..	..	920	264	656	7.2
Se 103	65	Onondaga limestone	10-23-48	422	..	.7	.01	..	..	..	171	156	22	..	..	184	140	44	7.8
Se 104	97	Pleistocene gravel	..	908	..	.2	.01	..	..	..	162	351	100	..	..	360	133	227	7.5
Se 119	178	Pleistocene gravel	10-25-48	2,250	..	7.8	.02	..	..	..	185	1,310	4	..	..	1,300	150	1,150	7.3
Se 126	268	Pleistocene till	10-25-48	4,450	..	6.6	.02	..	..	..	150	1,610	1,000	..	..	880	123	757	7.4
Se 127	20	Pleistocene sand	6-17-47	1,350	..	.2	.01	..	..	..	610	203	205	..	..	840	500	340	7.1
Se 133	165	Onondaga limestone	10-29-48	470	..	.18	.01	..	..	..	407	51	19	..	..	190	190	0	7.8
Se 174	33	Pleistocene deposits	6-21-47	1,080	..	4.3	.01	..	..	..	671	160	100	..	..	760	550	210	7.7
Se 175[a]	93	Onondaga limestone	5-23-49	440	8.0	.65	..	74	28	37	338	90	5	0.3	1.2	300	297	23	8.2
Se 180	187	Pleistocene sand	12-13-47	2,730	..	3.0	.13	..	..	..	117	1,730	125	..	..	1,900	100	1,800	7.4
Se 202	65	Hamilton group	10-25-48	384	..	.17	.01	..	..	..	345	57	5	..	..	310	283	27	7.5
Se 219	137	Pleistocene sand	10-25-48	389	..	.25	.01	..	..	..	273	84	8	..	..	20	20	0	8.5
Se 252	28	Pleistocene deposits	8-8-47	909	..	.12	.01	..	..	..	403	156	58	..	..	640	330	310	7.1
Se 256	75	Hamilton group	8-8-47	428	..	2.2	.01	..	..	..	395	64	2	..	..	440	324	116	7.4
Se 264[a]	87	Pleistocene gravel	5-23-49	714	14	2.76	..	79	40	79	156	291	66	3.0	1.0	362	128	234	8.3
Se 267	65	Salina formation	8-9-47	2,190	..	2.7	.01	..	..	..	350	1,170	4	..	..	1,650	290	1,360	7.1
Se 271[a]	75	Hamilton group	5-23-49	477	8.2	.16	..	94	26	20	284	109	20	0	12	341	233	108	8.2
Se 285	120	Hamilton group	9-13-47	788	..	12	.25	..	..	..	885	0	3	..	..	480	480	0	7.2
Se 308	115	Genesee group	10-25-48	451	..	.4	.04	..	..	..	389	81	1.0	..	..	300	300	0	7.3
Se 333	57	Genesee group	10-25-48	445	..	.17	.01	..	..	..	273	95	11	..	..	280	224	56	7.4
Se 338[b]	20	Pleistocene sand	7-15-48	...	..	.15	..	..	..	..	244	...	2.0	.05	.08	210	200	10	7.4
Se 343	54	Grimes-Wiscoy sequence	12-16-47	474	..	.15	.01	..	..	..	285	103	34	..	..	350	234	116	7.7
Se 362	265	Grimes-Wiscoy sequence	10-25-48	315	..	.05	.01	..	..	..	256	44	8	..	..	190	190	0	7.1
Se 370	68	Grimes-Wiscoy sequence	10-26-48	292	..	.09	.03	..	..	..	317	6	1	..	..	130	130	0	7.3
Se 379	17	Pleistocene deposits	10-25-48	420	..	.9	.01	..	..	..	176	41	44	..	..	190	144	46	7.4
Se 380	65	Hatch and Cashaqua shales	10-25-48	662	..	1.8	.10	..	..	..	401	135	40	..	..	460	329	131	7.1
Se 430	31	Hatch and Cashaqua shales	12-16-47	347	..	.03	.01	..	..	..	256	57	4	..	..	280	210	70	7.1
Se 465	10	Pleistocene gravel	12-16-47	348	..	.2	.01	..	..	..	314	40	2	..	..	290	257	33	7.5
Se 480	65	Pleistocene gravel	12-16-47	350	..	.2	.01	..	..	..	311	50	1	..	..	280	255	25	7.3
Se 499	44	Hatch and Cashaqua shales	12-16-47	473	..	1.0	.03	..	..	..	393	62	14	..	..	380	322	58	7.5
Se 503	50	Manlius and Cobleskill limestones	10-23-48	1,840	..	1.4	.01	..	..	..	292	915	57	..	..	1,000	239	761	6.9
Se 512[c]	75	Onondaga limestone	7-24-48	857	..	..	.0	145	58	..	390	300	29	..	.56	603	320	283	6.8
Se 5Sp	...	Onondaga limestone	10-25-48	596	..	.03	.01	..	..	..	289	148	56	..	..	310	237	73	7.4
Se 14Sp	...	Oriskany sandstone and Manlius limestone	10-25-48	2,180	..	.25	.01	..	..	..	326	1,010	170	..	..	940	267	673	7.1

[a] Analysis by U. S. Geological Survey, Quality of Water Branch.
[b] Analysis from records of the Mayor of the Village of Ovid, N. Y.
[c] Analysis from records of the G. L. F. Farm Products Coop., Inc., Waterloo, N. Y.

able for many domestic and nearly all industrial uses. Softening of municipal supplies is costly but generally profitable, particularly where the hardness is more than 300 parts per million. The cost may be reduced by mixing the very hard water with softer water from other wells or a stream, if available.

The hardness of the water samples collected in Seneca County ranged from 20 to 1,900 parts per million and averaged 558 parts per million. A comparison of the hardness of water withdrawn from unconsolidated deposits with that from the consolidated rocks shows that the former averaged 611 parts per million, approximately 53 parts higher. There was no definite indication of an increase in hardness with depth, but in several deep wells ending in the drift there was a vague suggestion of such an increase. Of the 42 analyses, only one showed a hardness much less than 150 parts per million. That sample, which had a hardness of 20 parts per million, was from an artesian well (Se 219) ending in a Pleistocene sand.

Hard water is objectionable in some processes in the soap, tanning, bleaching, high-grade-paper, dyeing, textile, and canning industries. Also, economical and satisfactory operation of commercial laundries requires water that has practically zero hardness. Most waters in Seneca County may be softened satisfactorily, although not always economically, by use of the zeolite (exchange-silicate) process or by the addition of lime or lime and soda ash.

In only six of the water samples withdrawn from wells tapping unconsolidated deposits did the noncarbonate hardness exceed the carbonate hardness. In each of these samples the sulfate content exceeded the carbonate content. The noncarbonate hardness seems to increase with the depth of the glacial materials. The reason for this may be that nearly all water having more noncarbonate than carbonate hardness is from areas where the drift overlies formations older than the Onondaga limestone, or where the drift is in the buried valleys that probably are cut through the Onondaga limestone and into the older formations. As may be noted in table 3, the thickness of the limestone between the Salina formation and the Onondaga limestone is insignificant. Thus, the large content of sulfate, which gives rise to the excessive amounts of noncarbonate hardness, may be explained in part by the probability that sulfate-bearing water from the members of the Salina formation, particularly the gypseous Camillus shale member, is infiltrating into the lower part of the drift. Another possibility may be that the drift in the northern part of Seneca County is rich in fragments and particles derived from the underlying gypseous Camillus shale member. The outcrop area of the Camillus is in the northernmost part of Seneca County and extends into adjacent parts of Wayne County. Water from shallow wells tapping the drift generally has an excess of carbonate hardness over noncarbonate hardness. This indirectly indicates a lower content of sulfate-bearing material in the drift, but it does not preclude the possibility that a greater amount of sulfate-bearing material was deposited in the drift and later leached out by a more active subsurface circulation of ground water.

The analyses of water samples obtained from wells tapping bedrock in Seneca County show that the carbonate hardness of the majority of samples tested exceeds the noncarbonate hardness. Again, the carbonate hardness is exceeded by noncarbonate hardness in only six of the analyses. As in the water obtained from Pleistocene deposits, the excess noncarbonate hardness is due to the presence of sulfate. It is interesting to note that only water from rock wells or springs that have penetrated or ended in formations older than the Oriskany sandstone (Lower Devonian) contains comparatively large amounts of noncarbonate hardness. In water withdrawn from rock wells ending in formations younger than the Oriskany sandstone, the carbonate hardness exceeds the noncarbonate hardness.

Iron

The presence of iron in water in quantities exceeding 0.3 part per million generaly results in its precipitation upon exposure of the water to air. Iron is objectionable because its presence imparts to the water a disagreeable taste or color, it permits rapid growth of iron-depositing bacteria which may lead to the clogging of water pipes, it has a tendency to stain plumbing fixtures and clothing and finally, it makes water unsuitable for food processing, baking, or canning. The removal of iron is fairly simple and inexpensive in public-supply systems but relatively more expensive in domestic-supply systems.

The water analyses in table 5 show a range in iron content from 0.03 to 15 parts per million and an average of 1.75 parts per million. The analyses of water from Pleistocene deposits shows an average iron content of 2.37 parts per million, the range being from 0.12 to 15.0 parts per million. The average is considerably greater than the acceptable tolerance. Analyses of samples from rock wells show an iron content averaging 1.27 parts per million. This is appreciably less than the

average in waters from Pleistocene materials but still is greater than the acceptable standards. The wide range in the iron content of the water from the unconsolidated materials may be explained in part by the presence of iron oxides in the drift, which were derived from the iron-rich formations that crop out to the north, in Wayne County. The beds of iron ore are in members of the Salina formation and older sandstones of the so-called Medina group. Marcasite occurs in several of the series of shales overlying the Onondaga limestone and also contributes to the iron content of water in rock wells.

Manganese

Manganese in amounts in excess of 0.05 part per million is undesirable as it results in a black discoloration of many materials it contacts. In addition, it clogs pipes and is very troublesome in laundering and in textile manufacturing. As shown in table 5, the manganese content of the ground water in Seneca County ranges from zero to 0.25 part per million. Most of the analyses indicate a manganese content ranging from 0.01 to 0.02 part per million. The greatest amount (0.25 ppm) was in a water sample from a rock well tapping shale of the Hamilton group (Se 285) and the smallest amount (less than 0.01 ppm) was in a well tapping the Onondaga limestone (Se 512). Ground water containing a comparatively large amount of iron also generally contained a comparatively large amount of manganese.

Chloride

Chloride is dissolved in small quantities from many rock materials and is one of the principal constituents of sea water. According to the standards of the American Water Works Association, water having a content of more than 250 parts per million of chloride is not acceptable for drinking. Chloride in amounts less than 400 parts per million cannot be tasted by most people, but in greater amount there is a noticeable taste. Livestock apparently can tolerate a content of chloride of several thousand parts per million. A high chloride content also increases the corrosiveness of the water, making it undesirable for industrial and commercial uses.

The chloride content of the samples of well water listed in table 5 ranges from 1.0 to 1,000 parts per million and averaged 58 parts per million. Samples from Pleistocene deposits have an average chloride content of 102 parts per million and range from 1.2 to 1,000 parts. On the other hand, samples from bedrock have an average of 25 parts per million and a range of only 1.0 to 571 parts.

It is interesting to note that water samples from wells in Pleistocene deposits having a greater-than-average chloride content are usually drawn from glacial drift in the buried rock valleys cut through the Onondaga limestone and older formations and into the underlying Salina formation. The high chloride content of water in the basal drift fill of the buried-valley region may be due to the infiltration of water from the underlying bedrock. As more highly mineralized water has a higher density, it would tend to be localized in the lower parts of the buried valleys. Flowing wells exist in the vicinity of Cosad, and one, Se 19, flows at an altitude of 500 feet. The reported depth of this well, which was originally drilled for natural gas, is 1,600 feet and it probably reaches the so-called Medina group. There are several other flowing artesian wells in the area, which were also unsuccessful gas wells, and in one the salinity of the overflow water was great enough to destroy the vegetation along its path of drainage.

Salt water also was reported to have been yielded by two wells drilled in the buried valley marked by the northerly extension of the old valley of Cayuga Lake, which today is roughly marked by the presence of Montezuma Marsh. The wells (Se 91 and Se 98) were drilled at the United States Montezuma Migratory Bird Refuge. At well Se 91, which was drilled to a depth of 100 feet in Pleistocene and Recent deposits, salt water was reported at levels of 53 and 76 feet. Well Se 98 was drilled to a depth of 705 feet, the Salina formation being encountered at 135 feet below the land surface. Salt water was reported in a quicksand 68 feet below land surface, at the contact of bedrock and the mantle of drift, and at five horizons in the bedrock. Natural gas at a pressure of 150 pounds per square inch was encountered at a depth of 705 feet.

Hydrogen-Ion Concentration (pH)

The pH value of water is important as an indicator of acidity or alkalinity. A neutral water has a pH value of 7.0; water having a pH above 7.0 is alkaline and water having a value below 7.0 is acid. Highly acid water is undesirable because it is very corrosive. In general, the ground water of Seneca County tends to be slightly alkaline, and the average pH value of 7.4. Only three analyses indicated values less than 7.0, and those were only slightly less.

TEMPERATURE

The temperature of ground water is important to industries and commercial establishments that require an inexpensive coolant or an economical method of air conditioning. According to Thwaites (1935, pp. 21-25), the temperature of ground water is about the same as the mean annual air temperature and is related to the depth within the earth from which the water is drawn. Because earth materials are of low conductivity, the seasonal change in temperature is slight at depths of more than a few feet, and at depths from which most ground water is drawn the change is generally less than a degree. A depth of 60 feet has been assumed by Thwaites to be roughly the level at which seasonal variation in the temperature of the ground water is completely damped out. Below that level the water temperature generally increases with depth, but the rate of increase is not uniform in all areas, nor are all the factors that influence temperature changes in ground water fully known. In general, however, the temperature of ground water increases about 1° F. for each increase of 50 to 100 feet in depth.

Approximately 90 measurements of ground-water temperature in Seneca County were made during the summer months. Most of the temperature measurements were in shallow wells, usually less than 55 feet in depth. In these, the temperature of the ground water ranged from 44° to 58° F., most of the readings ranging from 48° to 52° F. The variation in temperature of ground water drawn from shallow wells probably reflected changes in the air temperature. The average annual air temperature at Romulus is 47.8° F., the average spring, summer, and fall temperatures being 45.4°, 68.9°, and 51.5° F., respectively. Between the depths of 60 and 100 feet the water temperature ranged from 49° to 52° F., with only one exception. In the depth range between 100 and 200 feet, the temperature ranged from 50° to 52.5° F. In wells ranging from 250 to 1,600 feet in depth, water temperatures of 50° and 51° F. were recorded.

SUMMARY OF GROUND-WATER CONDITIONS

The consolidated rocks of Seneca County are predominantly shale and flagstone interbedded with limestone. The rocks are mantled nearly everywhere by unconsolidated deposits that range from thin beds of till of low permeability to comparatively thick beds of glacial outwash, some of which are highly permeable. In general, the unconsolidated deposits are thickest in buried valleys in the northern part of Seneca County and thinnest in the southern part of the County. The oldest rocks exposed in Seneca County are of Silurian age. The youngest deposits include the surficial mantle, laid down by continental ice sheets in Pleistocene time, and Recent Alluvium.

Nearly all the ground water in Seneca County is derived from precipitation that falls on the land surface and is absorbed by the mantle of surficial deposits. Ground water in some of the artesian aquifers in the northern part of Seneca County is derived from precipitation on outcrop areas north of the County. In most of Seneca County, ground water occurs under water-table conditions but artesian pressure has been observed in some wells, chiefly wells tapping consolidated rocks in the northern part of Seneca County. Furthermore, the quality of the ground water in deeply buried unconsolidated deposits—the comparatively large content of chloride and sulfate—suggests infiltration of water under artesian pressure from the underlying beds of salt and gypsum of the Salina formation.

The ground water in the surficial mantle is in the pore spaces between the grains of the unconsolidated material but in the bedrock is chiefly in joints, fractures, and other secondary openings.

Wells that tap the Camillus shale member of the Salina formation in its outcrop area in northern Seneca County are reported to yield as much as 400 gallons per minute. This water is suitable for most purposes. In contrast, however, water withdrawn from wells tapping the Camillus shale member south of its outcrop area is comparatively hard and has a large content of chloride and sulfate. In Seneca County, the Camillus shale member is immediately overlain by a sequence of thin-bedded limestone units. The upper unit of this sequence is the Onondaga limestone. Where the beds of limestone are overlain directly by surficial deposits, the yield of wells is as great as 200 gallons per minute. Water withdrawn from wells in limestone is suitable for most purposes but is hard. The yield from the limestone sequence is much less, however, where it is overlain by beds of shale, which tend to inhibit recharge and consequently retard the rate of solution along joints and fractures. South of the outcrop area of the Onondaga limestone and associated limestone sequence, the bedrock of Seneca County is predominantly shale. The yield of wells tapping the shale in the southern part of the County ranges from a quarter of a gallon to 60 gallons per minute, the yield apparently depending upon the thickness and character of the overburden. A large

number of failures of wells tapping the shale sequence above the Onondaga limestone are reported during periods of prolonged drought. The ground water in the beds of shale is comparatively soft and has a lower mineral content than that in the other consolidated rocks in Seneca County.

The surficial Pleistocene deposits of Seneca County consist of beds of lake clay and silt, deposits of unassorted till, and beds of coarse sand and gravel. On the average, the Pleistocene drift in the northern part of Seneca County is much thicker than that in the remainder of the County. The thickest deposits are in the valleys carved in bedrock by preglacial and interglacial streams, particularly the buried valleys that extend north of the Cayuga Lake and Seneca Lake troughs. The yield of the surficial deposits ranges from about half a gallon to 230 gallons per minute, the greatest yield being from wells tapping the coarser and better-assorted beds of outwash. The ground water in the Pleistocene drift, and in the bedrock also, is generally very hard. Eighteen analyses in table 5 indicate a range in hardness from 20 to 1,900 parts per million and an average hardness of 611 parts per million.

Ground water in Seneca County is recovered principally by pumping from dug or drilled wells. Of the 307 wells listed in table 7, 108 tap unconsolidated deposits, and most of these are dug wells. The remainder tap bedrock and most are drilled wells. A few driven wells have been installed along the shores of Cayuga Lake and Seneca Lake. About 95 percent of the wells in table 7 are at residences or farms and the average daily withdrawals at each one probably does not exceed 500 gallons per day for household supply or stock watering. Except for public-supply wells at two villages, the remaining 5 percent of the wells are at public institutions, commercial establishments, and industrial plants. Pumpage from these wells ranges from a few hundred gallons to about 300,000 gallons per day.

The public supply of the two largest villages in Seneca County, Seneca Falls and Waterloo, is obtained from Cayuga Lake and the Seneca River, respectively. The villages are in areas where a substantial supply of ground water could be developed. Use of ground water is not feasible, however, because in these areas the water is comparatively hard and contains large amounts of dissolved solids. The public supply of the next largest communities, the villages of Ovid and Interlaken, is ground water from wells and springs. The average withdrawal at Ovid is about 28,000 gallons per day and at Interlaken, 35,000 gallons per day.

It is estimated that the average daily withdrawal from all wells and springs in Seneca County is about 3,500,000 gallons per day. A much greater withdrawal could be made without depleting the underground reservoirs, particularly in the northern part of Seneca County. However, the ground water in many places in the County contains very large amounts of dissolved solids and can be used economically only for household purposes and stock watering. In many places in the southern part of Seneca County, the bedrock and the overburden are comparatively impermeable and only very small supplies of water can be recovered from the ground.

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Table 6.—Logs of selected wells in Seneca County, N. Y.

(See table 7 and plate 2 for records and locations of wells)

	Thickness (feet)	Depth (feet)
Se 15; 10M, 12.3N, 8.6W; E. F. Skinner, Waterloo; drilled by Barney Moravec.		
Sand and gravel	25	25
Clay and sand	70	95
Sand, coarse	5	100
Se 32; 10M, 16.2N, 9.4W; Art McIvor, Oaks Corners; drilled by Barney Moravec.		
Clay	10	10
Hardpan	10	20
Limestone, hard	130	150
Se 41; 10M, 16.7N, 7.9W; S. M. Fellows, Waterloo; drilled by Barney Moravec.		
Soil	3	3
Clay, sandy	7	10
Sand and boulders	10	20
Hardpan	7	27
Shale	10	37
Limestone, hard	84	121
Se 56; 10M, 11.4N, 5.4W; J. Heierman, Waterloo; drilled by N. Comstock.		
Clay	10	10
Sand and stone	15	25
Limestone, caving	40	65
Limestone, hard	10	75
Se 57; 10M, 11.0N, 4.4W; L. Norcott, owner; drilled by N. Comstock.		
Clay	12	12
Sand and stone	21	33
Hardpan	7	40
Limestone, caving	20	60
Limestone, hard	130	190
Se 59; 10M, 12.0N, 4.5W; W. H. Lawrence, Waterloo; drilled by Barney Moravec.		
Clay	10	10
Quicksand	10	20
Clay and sand	10	30
Hardpan and stones	3	33
Limestone, caving	27	60
Limestone, hard	14	74
Se 60; 10M, 12.5N, 4.5W; M. Walters, Waterloo; drilled by Barney Moravec.		
Clay	10	10
Sand	10	20
Clay and sand	5	25
Hardpan	5	30
Limestone, shaly	24	54
Limestone	104	158
Se 61; 10M, 12.7N, 4.6W; J. LaManna, Waterloo; drilled by Barney Moravec.		
Clay	10	10
Quicksand	10	20
Clay	10	30
Limestone, shaly	40	70
Limestone	15	85

Table 6.—Logs of selected wells in Seneca County, N. Y. (Continued)

	Thickness (feet)	Depth (feet)
Se 69; 10M, 13.1N, 3.4W; H. D. Saunders, Seneca Falls; drilled by Barney Moravec.		
Clay	12	12
Sand and stone	8	20
Gravel, cement	10	30
Hardpan	3	33
Limestone, hard	125	158
Se 81; 10M, 13.2N, 2.3W; R. C. Deming, Seneca Falls; drilled by Barney Moravec.		
Clay	10	10
Sand and boulders	10	20
Hardpan	10	30
Limestone, caving	15	45
Limestone, hard	102	147
Se 98; 9M, 2.5S, 0.5E; Montezuma Migratory Bird Refuge, Seneca Falls; drilled by Barney Moravec.		
Concrete	1.5	1.5
Clay and sand mixture	66.5	68
Quicksand (salt water)	10	78
Clay and sand mixture	7	85
Gravel, cemented	3	88
Hardpan	35	123
Clay, blue	12	135
Shale, red	30	165
Shale, soft, gray	11	176
Shale, soft, red	14	190
Shale, gray	48	238
Shale, soft, red	14	252
Shale, gray	28	280
Shale, brown	10	290
Shale, gray	45	335
Shale, calcareous	6	341
Shale, gray	9	350
Shale, brown	6	356
Shale, gray	39	395
Shale, brown	5	400
Shale, gray	20	420
Shale, brown	4	424
Shale, gray	21	445
Chalk, white	7	452
Rock, red	188	640
Shale, gray	45	685
Shale, brown (natural gas at 705 feet)	20	705
Se 103; 10M, 10.7N, 7.2W; G. R. Salisbury, Waterloo; drilled by Barney Moravec.		
Clay and sand	5	5
Quicksand	20	25
Sandstone	15	40
Limestone, hard	25	65
Se 104; 10M, 10.2N, 7.6W; W. H. Hart, Waterloo; drilled by N. Comstock.		
Clay and sand	20	20
Quicksand	25	45
Clay	20	65
Quicksand	20	85
Hardpan and gravel	12	97

Table 6.—Logs of selected wells in Seneca County, N. Y. (Continued)

Well	Description	Thickness (feet)	Depth (feet)
Se 108;	10M, 12.0N, 8.0W; W. Corner, Waterloo; drilled by Barney Moravec.		
	Clay	45	45
	Quicksand	15	60
	Sand, water	5	65
	Sand, fine, and gravel	5	70
	Clay and sand	35	105
	Sand and gravel	7	112
Se 115;	10M, 10.6N, 10.0W; H. Cook, Waterloo; drilled by N. Comstock.		
	Clay	12	12
	Clay and sand	12	24
	Quicksand	61	85
	Clay and sand	75	160
	Gravel	2	162
	Clay and sand	20	182
	Quicksand	20	202
	Clay and sand	16	218
	Limestone	7	225
Se 119;	10M, 12.6N, 10.9W; F. J. Racine, Geneva; drilled by Barney Moravec.		
	Sand	30	30
	Clay, light	2	32
	Quicksand	58	90
	Gravel	4	94
	Quicksand	81	175
	Gravel	3	178
Se 123;	10M, 8.9N, 10.5W; New York Electric and Gas Corp., Geneva; drilled by Alonzo Comstock.		
	Clay	12	12
	Clay and quicksand	20	32
	Quicksand	18	50
	Clay and sand	20	70
	Quicksand	30	100
	Quicksand and clay	25	125
	Clay and gravel	25	150
	Quicksand	50	200
	Onondaga limestone	136	336
Se 126;	10M, 10.1N, 10.1W; J. Clise, Waterloo; drilled by N. Comstock.		
	Clay	10	10
	Clay and sand	10	20
	Sand	50	70
	Clay	30	100
	Sand	50	150
	Quicksand	25	175
	Hardpan	93	268
Se 133;	10M, 6.9N, 4.6W; A. Poorman, Waterloo; drilled by N. Comstock.		
	Earth	5	5
	Rock, slate	90	95
	Limestone, hard	70	165
Se 138;	10M, 4.0N, 4.2W; L. Litzenberger, Romulus; drilled by N. Comstock.		
	Sand and boulders	20	20
	Shale, slate	20	40
	Slate, hard	50	90
	Slate, brown	110	200

Table 6.—Logs of selected wells in Seneca County, N. Y. (Continued)

		Thickness (feet)	Depth (feet)
	Slate, black	50	250
	Slate, brown	50	300
	Slate, blue	50	350
	Slate, brown	50	400
	Limestone, black	65	465
Se 172;	10M, 13.5N, 1.3W; Guaranteed Parts Co., Seneca Falls; drilled by P. Gardner.		
	Soil	5	5
	Clay	15	20
	Gravel, fine	10	30
	Gravel, coarse	10	40
Se 180;	10M, 10.9N, 10.7W; D. C. Doherty, owner; Waterloo; drilled by Barney Moravec.		
	Sand	20	20
	Clay and sand	15	35
	Quicksand	100	135
	Sand, coarse and fine	4	139
	Quicksand	48	187
Se 190;	10M, 11.7N, 5.4W; Village of Waterloo, Waterloo; drilled by Cranston & Son.		
	Topsoil	1	1
	Sand	1	2
	Clay, firm, red	42	45
	Clay, gravel, dark	3	48
	Gravel	6	54
	Boulder, gravel and clay	5.5	59.5
	Limestone with dark flint	9.5	69
	Limestone, hard	19	88
Se 191;	10M, 10.3N, 8.9W; Village of Waterloo, owner; Waterloo; drilled by Cranston & Son.		
	Topsoil	1	1
	Sand, yellow	3	4
	Clay, firm, red	10	14
	Clay, hard, silty	9	23
	Sand, very fine	22	45
	Sand, some clay	32	77
	Clay, soft	8	85
	Clay, red	19	104
	Clay, silty, some pebbles	10	114
	Clay, sandy and gravel, hard	4	118
	Limestone, hard	7	125
Se 194;	10M, 10.7N, 10.4W; Village of Waterloo, Waterloo; drilled by Cranston & Son.		
	Topsoil	1	1
	Sand, yellow	4	5
	Clay, red	5	10
	Clay, some gravel	5	15
	Sand, fine, yellow	3	18
	Sand, hard, gray, fine	27	45
	Clay	127	172
	Gravel	6	178
	Sand and gravel, coarse	18	196
	Sand and gravel	6	202

Table 6.—Logs of selected wells in Seneca County, N. Y. (Continued)

		Thickness (feet)	Depth (feet)
Se 197;	10M, 9.0N, 10.8W; Village of Waterloo, Waterloo; drilled by Cranston & Son.		
	Topsoil	1	1
	Clay, red	10	11
	Clay, silty	54	65
	Clay, soft, red	17	82
	Sand, very fine, silty	9	91
	Sand, fine, gray	22	113
	Clay, sandy	14	127
Se 198;	10M, 12.9N, 10.7W; Village of Waterloo, Waterloo; drilled by Cranston & Son.		
	Topsoil	1	1
	Clay, sandy	2	3
	Sand, fine	5	8
	Clay, sandy	37	45
	Clay, soft	6	51
	Sand and gravel	12	63
	Clay with gravel	11	74
	Clay, silty	31	105
	Clay, sandy	9	114
	Sand and gravel	6	120
	Quicksand	3	123
	Sand and gravel	3	126
	Clay	4	130
Se 200;	10M, 10.4N, 7.5W; A. W. Nash, Waterloo; drilled by N. Comstock.		
	Sand, yellow	15	15
	Clay	5	20
	Quicksand	24	48
	Limestone	17	65
Se 202;	10M, 4.1N, 4.9W; E. Warne, Jr., Romulus; drilled by Barney Moravec.		
	Clay and sand	16	16
	Shale, caving	24	40
	Rock	25	65
Se 220;	10M, 10.1N, 8.2W; J. Murray, Waterloo; drilled by N. Comstock.		
	Sand	5	5
	Clay	10	15
	Sand	20	35
	Clay	47	50
	Sand	5	55
	Clay	5	60
	Hardpan	5	65
	Limestone	15	80
Se 264;	10M, 9.5N, 9.1W; R. Conway, Waterloo; drilled by Barney Moravec.		
	Clay	10	10
	Sand	10	20
	Clay and sand	40	60
	Clay	10	70
	Hardpan	17	87
	Gravel, at	..	87

Table 6.—Logs of selected wells in Seneca County, N. Y. (Concluded)

		Thickness (feet)	Depth (feet)
Se 308;	10M, 4.9S, 4.5W; Starr Shaw, Hoyt Corners; drilled by Barney Moravec.		
	Sand and clay	5	5
	Hardpan	13	18
	Shale	34	52
	Shale, medium, hard	63	115
Se 310;	10M, 4.6S, 6.2W; F. Moses, Willard; drilled by Barney Moravec.		
	Sand and clay	5	5
	Hardpan	20	25
	Gravel	6	31
	Shale, medium, hard	126	157
Se 346;	10M, 12.3N, 1.8W; C. Cross, Seneca Falls; drilled by Paul Gardner.		
	Clay	5	5
	Sand, coarse, brown	15	20
	Hardpan	24	44
	Limestone	67	111
Se 476;	10M, 9.2N, 9.5W; W. Regal, Waterloo; drilled by N. Comstock.		
	Soil	5	5
	Quicksand	40	45
	Clay, blue, with some quicksand	55	100
	Hardpan	10	110
	Limestone	2.5	112.5
Se 498;	10M, 9.0N, 10.6W; H. Nerber, Waterloo; drilled by N. Comstock.		
	Clay	20	20
	Quicksand	40	60
	Clay	10	70
	Clay and sand	65	135
Se 500;	10M, 10.7N, 4.2W; Nothnagel and Pratz, Seneca Falls; drilled by P. Gardner.		
	Soil	5	5
	Clay	5	10
	Sand, yellow	30	40
	Limestone	16	56
Se 509;	9M, 0.1N, 6.8W; G. Serven, Waterloo; drilled by P. Gardner.		
	Soil	2	2
	Clay	9	11
	Hardpan	7	18
	Sand and gravel	10	20
	Sand, gray	5	25
	Limestone	15	40
Se 513;	9M, 0.0N, 0.7W; L. Prosser, Savannah.		
	Soil	7	7
	Quicksand	2	9
	Hardpan	6	15
	Quicksand	1.5	16.5
	Clay, blue	5	21.5
	Sand and gravel	1.5	23
Se 515;	10M, 2.9S, 1.9W; S. Swinehart, Ovid; drilled by N. Comstock.		
	Soil, sandy	4	4
	Hardpan	26	30
	Shale	15	45
	Shale, hard	134	179

Table 7.—Records of selected wells in Seneca County, New York

Location: For explanation of location symbols see section "Methods of investigation."
Altitude above sea level: Approximate altitude from topographic map.
Type of well: Drl, drilled; Drv, driven.

Water level below land surface: Reported average water level.
Method of lift: For explanation of methods of lift and pumping equipment see section "Recovery."
Use: Com, commercial; Dom, domestic; Ind, industrial; PWS, public water supply; Irr, irrigation.

Well number	Location	Owner	Altitude above sea level (feet)	Type of well	Depth (feet)	Diameter (inches)	Depth to bedrock (feet)	Geologic subdivision	Water level below land surface (feet)	Method of lift	Yield (gallons per minute)	Temperature (° F.)	Use	Remarks
Se 1	10M, 0.1N, 4.1W	Seneca County Highway Department	720	Drl	65	6	4	Hamilton group	8	..	10	..	Com	Water level in well reported to recover in 15 minutes after well is pumped dry
Se 2	10M, 0.0N, 4.2W	J. W. Coryell	720	Drl	40	6	40	Pleistocene till	..	..	4	..	Dom	
Se 3	10M, 1.1N, 4.3W	Peter Murphy	700	Dug	31	31	...	Pleistocene deposits	13	..	15	51	Farm	
Se 4	10M, 1.9N, 4.5W	Harry Guilfoos	690	Drl	80	6	12	Hamilton group	10	..	10	..	Farm	Water level in well reported to recover rapidly after well is pumped dry.
Se 6	10M, 4.2N, 5.1W	E. Mudge	700	Drl	33	6	20	Hamilton group	9	Suction	5	..	Farm	Water reported to have a rust color.
Se 7	10M, 5.7N, 5.0W	E. P. Johnson	650	Drl	160	6	5	Hamilton group	12	..	10	..	Farm	
Se 8	10M, 6.9N, 5.2W	Bertha Brown	580	Drl	145	6	10	Hamilton group	15	..	5	..	Dom	Water reported to contain hydrogen sulfide.
Se 9	10M, 8.2N, 5.3W	James Dewall	560	Drl	149	6	4	Hamilton group	82	Force	6	..	Farm	Water reported to contain hydrogen sulfide.
Se 11	10M, 11.6N, 6.1W	M. E. Unger	500	Dug	38	36	...	Pleistocene outwash	2	Suction	10	50	Dom	
Se 12	10M, 11.7N, 6.4W	D. Weaver	500	Drl	90	6	30	Onondaga limestone	..	Jet	5	..	Dom	
Se 14	10M, 12.0N, 7.4W	Philip Dorf	500	Dug	16	36	...	Pleistocene outwash	0.5	Suction	5	55	Dom	(a)
Se 15	10M, 12.3N, 8.6W	E. F. Skinner	520	Drl	100	6	...	Pleistocene sand	10	..	15	..	Dom	(b)
Se 16	10M, 13.3N, 8.8W	Donald Kaufman	480	Drl	117	6	80	Salina formation	35	Force	60	..	Farm	
Se 17	10M, 13.9N, 8.9W	Dan McGuane	500	Dug	55	30	...	Pleistocene outwash	3	Suction	10	..	Dom	
Se 19	10M, 14.1N, 8.7W	Charles Albro	500	Drl	1,600	10	...	Medina group of various authors	..	..	100	51	Farm	Well originally drilled for gas; now a flowing water well. Water contains hydrogen sulfide.[a]
Se 20	10M, 13.3N, 7.7W	H. Manwaring	510	Drl	52	6	...	Pleistocene gravel	..	..	125	..	Farm	
Se 21	10M, 13.6N, 7.8W	B. DeWall	520	Drl	122	6	103	Salina formation	58	Force	30	..	Farm	
Se 24	10M, 12.7N, 5.5W	Louis Burgess	480	Drl	132	6	26	Salina formation	32	Force	20	..	Farm	
Se 25	10M, 12.7N, 5.6W	Louis Burgess	480	Drl	75	6	24	Salina formation	15	Force	10	..	Farm	
Se 26	10M, 14.2N, 8.2W	L. H. Kerry	500	Dug	15	36	...	Pleistocene deposits	1	Suction	20	..	Farm	
Se 27	10M, 14.2N, 8.3W	L. H. Kerry	500	Drl	800	8	20	Salina formation	5	Suction	10	50	Farm	Well originally drilled for gas; high mineral content reported.
Se 28	10M, 15.1N, 9.1W	K. Donnely	510	Drl	84	6	...	Pleistocene till	40	Jet	10	..	Farm	Water level in well reported to recover 2 hours after well is pumped dry. Water contains hydrogen sulfide.
Se 31	10M, 17.0N, 9.5W	Karl Jacobs	420	Dug	16	36	...	Pleistocene deposits	8	Suction	5	51	Dom	

See footnotes at end of table.

Table 7.—Records of selected wells in Seneca County, New York (Continued)

Well number	Location	Owner	Altitude above sea level (feet)	Type of well	Depth (feet)	Diameter (inches)	Depth to bedrock (feet)	Geologic subdivision	Water level below land surface (feet)	Method of lift	Yield (gallons per minute)	Temperature (° F.)	Use	Remarks
Se 32	10M, 16.2N, 9.4W	Arthur McIvor	480	Drl	150	6	20	Salina formation	18	Force	5	..	Dom	(a) (b)
Se 33	10M, 15.6N, 9.2W	Grover Smith	480	Drl	71	6	...	Pleistocene gravel	7	..	60	..	None	
Se 34	10M, 14.7N, 10.3W	L. Backus	520	Drl	62	6	...	Pleistocene gravel	10	Suction	5	..	Dom	(a)
Se 35	10M, 14.6N, 10.7W	E. Green	500	Dug	12	36	...	Pleistocene gravel	4.4	Suction	5	51	Dom	
Se 38	10M, 16.9N, 9.0W	H. Mierke	420	Dug	22	36	...	Pleistocene deposits	6.8	Suction	5	52	Dom	
Se 39	10M, 17.2N, 10.1W	Ludger Boisvert	405	Dug	14	36	...	Pleistocene deposits	7.8	Suction	5	51	Dom	(a)
Se 41	10M, 16.7N, 7.9W	S. M. Fellows	500	Drl	121	6	27	Salina formation	15	Jet	10	..	Farm	(b)
Se 43	10M, 16.0N, 7.8W	K. Mills	500	Dug	22	24	9	Salina formation	8	Jet	15	52	Farm	
Se 44	10M, 14.9N, 7.9W	G. H. Lutz	520	Dug	39	36	...	Pleistocene deposits	9.8	Suction	5	53	Dom	(a)
Se 45	10M, 14.1N, 7.8W	Fritz Heitman, Sr.	520	Drl	71	6	68	Salina formation	40	Jet	8	..	Farm	
Se 47	10M, 16.2N, 7.0W	E. C. Pearson	520	Dug	20	36	20	Pleistocene gravel	12.4	..	5	50	Dom	
Se 50	9M, 1.2N, 6.7W	J. L. Godfrey	480	Dug	31	36	31	Pleistocene till	10	Force	5	..	Dom	
Se 51	9M, 0.5N, 7.3W	Myron Garrett	480	Dug	25	36	...	Pleistocene till	15	Jet	15	..	Dom	
Se 53	10M, 16.2N, 6.0W	E. Pigman	500	Drl	42	6	26	Salina formation	16	..	25	..	Dom	
Se 54	10M, 15.5N, 6.3W	Fred Schweitz	520	Drl	26	6	18	Salina formation	21	Force	15	..	Farm	
Se 55	10M, 14.5N, 5.8W	Ray Hanvill	507	Drl	18	6	...	Pleistocene gravel	1.5	Suction	5	54	Dom	
Se 56	10M, 11.4N, 5.4W	John Heierman	480	Drl	75	6	65	Onondaga limestone	27	Force	7	..	Dom	Water reported to be red in color.[b]
Se 57	10M, 11.0N, 4.4W	L. Norcott	460	Drl	190	6	40	Manlius and Rondout limestones and Cobleskill dolomite	..	Force	10	..	Farm	(b)
Se 59	10M, 12.0N, 4.5W	W. H. Lawrence	480	Drl	74	6	33	Manlius and Rondout limestones and Cobleskill dolomite	20	Suction	30	..	Farm	(b)
Se 60	10M, 12.5N, 4.5W	M. Walters	480	Drl	158	6	30	Salina formation	20	..	60	..	Dom	(b)
Se 61	10M, 12.7N, 4.6W	Joseph LaManna	480	Drl	85	6	30	Salina formation	20	..	50	..	Dom	(a) (b)
Se 62	10M, 13.6N, 4.8W	Charles Deal	480	Dug	73	36	...	Pleistocene deposits	3.3	Hand	10	51	Dom	
Se 63	10M, 14.6N, 4.9W	R. C. Russell	520	Dug	30	36	30	Pleistocene till	19	..	10	52	Dom	
Se 64	10M, 16.0N, 5.0W	F. W. Struble	500	Drl	285	6	30	Salina formation	18	..	30	..	Dom	
Se 66	9M, 0.2N, 4.3W	F. J. Schoonmaker	480	Dug	24	36	...	Pleistocene gravel	14.3	..	5	48	Dom	
Se 68	10M, 12.4N, 3.3W	Lorenzo Cammaso	470	Drl	110	6	50	Salina formation	25	Force	20	..	Farm	
Se 69	10M, 13.1N, 3.4W	H. D. Saunders	485	Drl	158	6	33	Salina formation	21	Force	15	..	Farm	(b)
Se 70	10M, 14.0N, 3.5W	E. S. Worden	500	Drl	30	..	...	Pleistocene deposits	5.7	Suction	15	50	Dom	(a)
Se 71	10M, 14.7N, 3.6W	Lenora Westbrook	500	Drl	110	6	38	Salina formation	15	Force	60	..	Farm	
Se 73	10M, 16.6N, 4.5W	Frank Griggs	460	Dug	30	36	...	Pleistocene deposits	10	Suction	5	..	Dom	

See footnotes at end of table.

Table 7.—Records of selected wells in Seneca County, New York (Continued)

Well number	Location	Owner	Altitude above sea level (feet)	Type of well	Depth (feet)	Diameter (inches)	Depth to bedrock (feet)	Geologic subdivision	Water level below land surface (feet)	Method of lift	Yield (gallons per minute)	Temperature (° F.)	Use	Remarks
Se 74	10M, 17.1N, 3.8W	K. Sutterby	440	Drl	39	6	...	Pleistocene gravel	15	Force	5	..	Farm	
Se 80	10M, 12.9N, 2.2W	T. D. Masten	480	Drl	48	6	...	Pleistocene gravel	22	..	50	..	Farm	
Se 81	10M, 13.2N, 2.3W	R. C. Deming	500	Drl	147	6	33	Salina formation	50	Jet	20	..	Farm	(a) (b)
Se 83	10M, 14.1N, 3.0W	J. A. Jones	460	Dug	26	36	...	Pleistocene till	18	..	5	..	Dom	
Se 84	10M, 13.7N, 2.3W	H. L. Cone	500	Drl	38	6	17	Salina formation	20	Jet	60	..	Farm	
Se 85	10M, 14.5N, 2.3W	E. J. Mitchell	480	Drl	32	6	32	Pleistocene deposits	20	..	10	..	Farm	
Se 86	10M, 15.3N, 2.3W	E. Troutman	460	Drl	92	6	24	Salina formation	22	..	8	..	Farm	Well reported to flow when first drilled.
Se 87	10M, 16.0N, 2.9W	G. B. Van Riper	480	Drl	43	6	20	Salina formation	30	Force	10	..	Farm	
Se 89	10M, 16.0N, 1.9W	Jesse Rogers	430	Dug	14	36	...	Pleistocene deposits	8	Suction	15	..	Farm	Water level in well reported to recover within half an hour after well is pumped dry.
Se 90	10M, 15.2N, 1.3W	Jessie A. Lay	420	Dug	24	36	...	Pleistocene deposits	10	Suction	5	48	Farm	
Se 91	10M, 16.5N, 1.1W	Montezuma Migratory Bird Refuge	390	Drl	100	6	...	Pleistocene gravel	8	..	..	..	None	Driller reports principal water-bearing beds, between depths of 53 and 76 feet, to yield salt water.
Se 92	10M, 12.1N, 1.9W	Southern Oil Co.	470	Drl	89	6	89	Pleistocene gravel	30	Force	20	..	Com	
Se 94	10M, 13.0N, 1.3W	Heddens Cabins	420	Drl	140	6	44	Salina formation	30	Suction	60	..	Com	
Se 96	10M, 14.1N, 1.0W	Lester DeLelys	440	Dug	16	36	...	Pleistocene deposits	10	Suction	10	48	Dom	
Se 97	10M, 12.6N, 2.3W	W. Ward	490	Drl	55	6	...	Pleistocene gravel	30	Force	10	..	Farm	
Se 98	9M, 2.5S, 0.5E	Montezuma Migratory Bird Refuge	390	Drl	705	6	135	Salina formation	..	..	..	..	None	Well reported to yield salt water at depths greater than 68 feet and gas under 150 pounds pressure at 705 feet.[b]
Se 99	10M, 16.9N, 2.6W	H. L. Kline	400	Drl	100	6	15	Salina formation	5	Suction	60	..	Dom	
Se 101	10M, 11.1N, 6.5W	William Marion	460	Dug	18	36	...	Pleistocene sand	4	Suction	5	48	Dom	
Se 102	10M, 11.1N, 7.5W	C. Griffith	460	Dug	10	36	...	Pleistocene sand	5.8	Suction	20	48	Farm	
Se 103	10M, 10.7N, 7.2W	G. R. Salisbury	460	Drl	65	6	40	Onondaga limestone	12	..	5	..	Dom	(a) (b)
Se 104	10M, 10.2N, 7.6W	W. H. Hart	470	Drl	97	6	...	Pleistocene gravel	59	Jet	30	..	Dom	(a) (b)
Se 105	10M, 10.0N, 8.1W	H. J. Mishoe	470	Drl	80	6	68	Onondaga limestone	3	Jet	50	..	Com	
Se 107	10M, 11.6N, 7.9W	Willard Paine	485	Drl	117	6	...	Pleistocene gravel	24	Force	15	..	Dom	
Se 108	10M, 12.0N, 8.0W	W. Corner	510	Drl	112	6	...	Pleistocene gravel	20	..	10	..	Dom	Water reported high in mineral content.[b]
Se 109	10M, 12.7N, 7.7W	George Lafler	500	Drl	86	6	...	Pleistocene deposits	20	Force	50	..	Farm	
Se 110	10M, 12.2N, 9.6W	C. H. Mills	500	Drl	92	6	...	Pleistocene deposits	30	Force	..	..	None	Well not in use; high iron content reported.
Se 112	10M, 9.8N, 8.6W	C. E. Weir	460	Drl	73	6	50	Onondaga limestone	20	..	30	..	Dom	

See footnotes at end of table.

Table 7.—Records of selected wells in Seneca County, New York (Continued)

Well number	Location	Owner	Altitude above sea level (feet)	Type of well	Depth (feet)	Diameter (inches)	Depth to bedrock (feet)	Geologic subdivision	Water level below land surface (feet)	Method of lift	Yield (gallons per minute)	Temperature (° F.)	Use	Remarks
Se 115	10M, 10.6N, 10.0W	Harry Cook	480	Drl	225	6	218	Onondaga limestone	35	..	2	..	Dom	Well reported to have yielded 55 gallons per minute at depth of 160 feet, but water contained a large amount of sand.[b]
Se 119	10M, 12.6N, 10.9W	F. J. Racine	530	Drl	178	6	...	Pleistocene gravel	65	Force	30	..	Dom	Small amount of water reported at 90 feet.[a b]
Se 120	10M, 13.2N, 10.9W	R. E. Yackel	560	Drl	173	6	143	Salina formation	88	..	5	..	Dom	
Se 122	10M, 9.9N, 10.9W	H. Valerio	460	Dug	10	36	...	Pleistocene gravel	4	Suction	10	..	Dom	
Se 123	10M, 8.9N, 10.5W	New York Electric & Gas Corp.	460	Drl	336	8	200	Onondaga limestone	+1	None	10	..	None	Well reported to flow for past 20 years. Water contains hydrogen sulfide.[b]
Se 126	10M, 10.1N, 10.1W	James Clise	480	Drl	268	6	...	Pleistocene till	20	Force	75	..	Dom	Water reported high in mineral content.[a b]
Se 127	10M, 10.4N, 4.7W	E. M. Odell	438	Dug	20	36	...	Pleistocene sand	12	..	5	..	Dom	([a])
Se 130	10M, 8.5N, 4.6W	L. J. Poorman	480	Drl	50	6	18	Onondaga limestone	23	Force	20	..	Farm	
Se 132	10M, 7.9N, 4.6W	L. J. Poorman	500	Dug	20	36	...	Pleistocene deposits	8.2	Suction	5	48	Dom	
Se 133	10M, 6.9N, 4.6W	A. Poorman	590	Drl	165	6 to 4	5	Onondaga limestone	128	..	15	..	Farm	([a]) ([b])
Se 134	10M, 6.9N, 4.6W	A. Poorman	590	Drl	75	6	5	Hamilton group	0	Jet	15	..	Farm	
Se 135	10M, 5.6N, 4.3W	H. C. and Fred Nash	610	Drl	60	6	...	Pleistocene gravel	20	Force	5	..	Dom	
Se 138	10M, 4.0N, 4.2W	L. Litzenberger	690	Drl	465	6 to 4	30	Onondaga limestone	40	..	1	..	Farm	Water reported to contain hydrogen sulfide.[b]
Se 141	10M, 9.3N, 3.7W	J. B. Crough	480	Drl	100	6	30	Onondaga limestone	20	Force	50	..	Farm	
Se 142	10M, 8.7N, 3.6W	H. McCoy	500	Drl	120	..	6	Onondaga limestone	10	Jet	15	..	Farm	Decrease in yield reported during periods of low precipitation.
Se 143	10M, 8.1N, 3.1W	R. W. Steele	520	Dug	22	24	22	Pleistocene deposits	4	Suction	3	..	Dom	Well reported to fail during periods of low precipitation.
Se 145	10M, 7.4N, 2.4W	S. Neal	580	Drl	73	6	3	Onondaga limestone	30	Force	2	..	Farm	
Se 146	10M, 6.1N, 2.8W	H. E. Sisson	540	Drl	75	6	9	Hamilton group	5	..	3	..	None	Well not used.
Se 148	10M, 8.6N, 2.7W	G. F. Kimmell	480	Drl	71	6	24	Onondaga limestone	18	..	8	..	Farm	
Se 150	10M, 10.6N, 1.1W	A. Barbieri	460	Dug	28	36	...	Pleistocene deposits	20.9	Force	15	50	Farm	
Se 151	10M, 9.7N, 1.4W	Joseph Robert	460	Dug	25	36	...	Pleistocene deposits	4.6	Suction	20	..	Farm	
Se 153	10M, 8.8N, 1.3W	C. L. Brown	480	Dug	25	36	...	Pleistocene outwash	4.2	Suction	5	..	Dom	
Se 155	10M, 7.7N, 1.5W	F. Holster	470	Dug	13	48	13	Pleistocene deposits	6	Suction	5	..	Dom	
Se 156	10M, 7.0N, 1.5W	W. Holster	520	Drl	135	6	5	Onondaga limestone	100	Force	15	..	Farm	
Se 157	10M, 6.0N, 1.6W	Arthur Gaines	580	Drl	67	6	...	Hamilton group	27.5	Force	10	52	Farm	
Se 158	10M, 9.6N, 0.8W	Frank Dean	460	Dug	27	30	...	Pleistocene outwash	7.6	Suction	15	..	Farm	

See footnotes at end of table.

Table 7.—Records of selected wells in Seneca County, New York (Continued)

Well number	Location	Owner	Altitude above sea level (feet)	Type of well	Depth (feet)	Diameter (inches)	Depth to bedrock (feet)	Geologic subdivision	Water level below land surface (feet)	Method of lift	Yield (gallons per minute)	Temperature (° F.)	Use	Remarks
Se 159	10M, 8.6N, 0.8W	F. & H. Perry	460	Drl	67	6	30	Onondaga limestone	18	Jet	20	..	Farm	
Se 164	10M, 5.9N, 1.0W	Lancing Frankenfield	500	Drl	42	6	37	Salina formation	..	Jet	20	..	Farm	
Se 166	10M, 4.8N, 1.8W	B. Stowell	530	Dug	25	36	...	Pleistocene deposits	10	Suction	5	54	Dom	
Se 167	10M, 3.0N, 3.2W	C. E. Kaufman	660	Dug	20	36	20	Pleistocene till	16	Force	10	46	Farm	
Se 171	10M, 11.1N, 3.4W	Gould Pumps, Inc.	450	Drl	385	10 to 8	52	Salina formation	50	..	400	..	None	Well not used; salt water encountered from 440 to 450 feet; well plugged at 385 feet.
Se 172	10M, 13.5N, 1.3W	Guaranteed Parts Co.	440	Drl	40	8	...	Pleistocene gravel	23	Jet	5	..	Dom	First water reported at 30 feet.[b]
Se 173	10M, 13.5N, 1.0W	Pottery Manufacturers Exhibit	440	Drl	45	6	...	Pleistocene sand	28	Jet	5	..	Dom	
Se 174	10M, 9.3N, 2.6W	E. W. Sanders	480	Drl	33	6	...	Pleistocene deposits	9.6	Suction	5	48	Dom	([a])
Se 175	10M, 9.1N, 3.3W	Seneca County Home	470	Drl	93	6	3	Onondaga limestone	20	Suction	10	52	Dom	([a])
Se 176	10M, 8.9N, 2.7W	A. L. Wheeler	480	Drl	66	6	27	Onondaga limestone	46	Force	5	..	Dom	
Se 177	10M, 4.6N, 3.1W	Joseph Sorrentino	610	Drl	85	6	5	Hamilton group	16	Jet	10	..	Com	Show of water reported at 50 feet.
Se 180	10M, 10.9N, 10.7W	D. C. Doherty	476	Drl	187	6 to 4	...	Pleistocene sand	20	Force	50	..	None	Well not used; quicksand.[a b]
Se 184	10M, 10.1N, 8.2W	Harold Kopf	440	Drl	63	6	46	Manlius and Rondout limestones and Cobleskill dolomite	8	..	10	..	Com	Driller reports 40 feet of clay and 6 feet of sand above bedrock and some water between 40 and 46 feet in depth.
Se 185	10M, 10.3N, 7.4W	Donald Taber	460	Drl	79	6	70	Onondaga limestone	27	Force	50	..	Dom	
Se 188	10M, 11.0N, 5.1W	Village of Waterloo	470	Drl	65	10	59	Onondaga limestone	..	..	..	..	None	Village test hole 1; small yield reported at 56 feet; casing pulled.
Se 189	10M, 11.3N, 5.6W	Village of Waterloo	485	Drl	40	10	23	Onondaga limestone	..	..	..	..	None	Village test hole 2; casing pulled.
Se 190	10M, 11.7N, 5.4W	Village of Waterloo	490	Drl	88	10 to 8	59	Onondaga limestone	41	..	48	..	None	Village test hole 3; drawdown reported 20 feet after pumping at rate of 48 gallons per minute for 12 hours.[b]
Se 191	10M, 10.3N, 8.9W	Village of Waterloo	470	Drl	125	10 to 8	118	Onondaga limestone	..	..	5	..	None	Village test hold 4; abandoned; driller reported yield of 5 gallons per minute at 118 feet.[b]
Se 192	10M, 10.3N, 9.2W	Village of Waterloo	475	Drl	116	10 to 8	112	Onondaga limestone	..	..	..	..	None	Village test hole 5; abandoned.
Se 193	10M, 10.5N, 9.6W	Village of Waterloo	480	Drl	140	10 to 8	135	Onondaga limestone	..	..	..	..	None	Village test hole 6; abandoned.
Se 194	10M, 10.7N, 10.4W	Village of Waterloo	485	Drl	202	10 to 6	...	Pleistocene gravel	23	..	225	..	None	Village test hole 7; abandoned; drawdown reported 2 feet after pumping at rate of 225 gallons per minute for 5 hours.[b]
Se 195	10M, 10.7N, 10.6W	Village of Waterloo	470	Drl	175	10 to 6	...	Pleistocene gravel	16	..	230	..	None	Village test hole 8; drawdown reported 6 feet after pumping at rate of 230 gallons per minute for 4 hours.

See footnotes at end of table.

Table 7.—Records of selected wells in Seneca County, New York (Continued)

Well number	Location	Owner	Altitude above sea level (feet)	Type of well	Depth (feet)	Diameter (inches)	Depth to bedrock (feet)	Geologic subdivision	Water level below land surface (feet)	Method of lift	Yield (gallons per minute)	Temperature (° F.)	Use	Remarks
Se 196	10M, 8.7N, 10.1W	Village of Waterloo	450	Drl	135	10 to 8	...	Pleistocene clay and gravel	..	..	..	..	None	Village test hole 9; abandoned; no appreciable yield.
Se 197	10M, 9.0N, 10.8W	Village of Waterloo	465	Drl	127	10 to 8	...	Pleistocene clay	..	..	..	..	None	Village test hole 10; abandoned; small yield reported at 91 feet.[b]
Se 198	10M, 12.9N, 10.7W	Village of Waterloo	510	Drl	130	10 to 8	...	Pleistocene gravel	27	..	65	..	None	Village test hole 11; drawdown reported 6 feet after pumping at rate of 65 gallons per minute.[b]
Se 199	10M, 10.0N, 8.3W	Charles Covert	460	Drl	60	6	60	Pleistocene sand	..	Force	30	..	Dom	
Se 200	10M, 10.4N, 7.5W	A. W. Nash	465	Drl	65	6	48	Onondaga limestone	35	Jet	30	..	Dom	([b])
Se 202	10M, 4.1N, 4.9W	E. Warne, Jr.	700	Drl	65	6	16	Hamilton group	20	..	60	..	Dom	([a]) ([b])
Se 203	10M, 2.8N, 4.9W	E. Smith	700	Drl	83	6	20	Hamilton group	10	Suction	10	..	Dom	
Se 206	10M, 11.1N, 5.4W	G. L. F. Farm Products Coop., Inc.	420	Drl	107	6	56	Onondaga limestone	..	..	80	..	Ind	
Se 207	10M, 11.9N, 6.1W	H. C. Andrews	495	Drl	68	8	54	Onondaga limestone	32	..	60	..	Irr	Well has been pumped continuously for periods up to 3 weeks.
Se 208	10M, 11.6N, 5.7W	H. C. Andrews	500	Drl	168	8	118	Onondaga limestone	50	..	83	..	Farm	
Se 209	10M, 0.1S, 4.2W	N. W. Trainor	740	Drl	70	6	4	Hamilton group	10	Suction	4	..	Dom	
Se 211	10M, 1.5N, 3.2W	W. K. Newman	695	Drl	787	8	30	Salina formation	100	Force	150	..	Farm	Principal water-bearing bed penetrated at depth of 610 feet. Water contains small flakes of gypsum.
Se 212	10M, 1.6N, 2.1W	H. F. Manvig	610	Drl	290	6	20	Hamilton group	170	Force	2½	..	Dom	
Se 216	10M, 0.7N, 2.2W	Harry Warne	630	Drl	60	6	22	Hamilton group	10	Jet	20	..	Farm	
Se 217	10M, 0.2N, 2.2W	Carlton Warne	620	Drl	100	6	12	Hamilton group	20	Jet	15	..	Farm	
Se 218	10M, 1.2N, 1.5W	A. W. Hicks	540	Drl	119	6	119	Pleistocene deposits	3	Suction	10	..	Dom	
Se 219	10M, 1.6N, 1.0W	E. R. Hazard	390	Drl	137	6	...	Pleistocene sand	..	None	10	..	Dom	Well flows; hydrostatic pressure of 14 pounds per square inch is reported.[a]
Se 220	10M, 10.1N, 8.2W	John Murray	460	Drl	80	6	65	Onondaga limestone	3	..	50	..	None	([b])
Se 223	10M, 8.8N, 7.1W	Elmer Youngs	520	Dug	75	48	12	Hamilton group	4	Suction	6	..	Farm	
Se 224	10M, 8.4N, 8.7W	Gus Christensen	500	Dug	20	48	...	Pleistocene deposits	6	Jet	10	..	Farm	
Se 226	10M, 7.8N, 8.8W	Bornheimer Brothers	540	Drl	100	6	8	Hamilton group	30	Force	1	..	Farm	Water contains hydrogen sulfide
Se 228	10M, 7.0N, 8.4W	Frank Kline	590	Drl	84	6	40	Hamilton group	39	Jet	20	..	Farm	
Se 229	10M, 6.3N, 7.4W	Louis Freier	560	Drl	65	6	30	Hamilton group	30	Jet	30	..	Farm	
Se 230	10M, 10.0N, 6.9W	Louis Freier	460	Drl	167	6	4	Salina formation	10	..	30	..	Farm	

See footnotes at end of table.

Table 7.—Records of selected wells in Seneca County, New York (Continued)

Well number	Location	Owner	Altitude above sea level (feet)	Type of well	Depth (feet)	Diameter (inches)	Depth to bedrock (feet)	Geologic subdivision	Water level below land surface (feet)	Method of lift	Yield (gallons per minute)	Temperature (° F.)	Use	Remarks
Se 233	10M, 8.8N, 8.8W	Orville Covert	480	Drl	108	6	8	Onondaga limestone	20	..	20	..	Farm	Water contains hydrogen sulfide.
Se 234	10M, 8.3N, 9.6W	E. M. Chamberlin	520	Drl	1,400+	6	5	Medina group of authors	+1.9	None	..	..	None	Well not used; water contains hydrogen sulfide.
Se 236	10M, 6.9N, 9.3W	H. J. Kipp	520	Drl	89	6	8	Hamilton group	35	Force	½	..	Dom	
Se 237	10M, 5.0N, 8.8W	Fred Lerch	600	Drl	150	6	5	Hamilton group	18	Jet	3	..	Farm	Driller reports small yield at 40 feet.
Se 238	10M, 5.6N, 7.7W	S. O. Nielsen	530	Drl	178	6	6	Hamilton group	..	..	6	..	Farm	
Se 239	10M, 9.5N, 6.0W	Joseph Miller	480	Drl	135	6	15	Onondaga limestone	60	Force	40	..	Farm	
Se 240	10M, 7.7N, 5.9W	Paul Sigrist	560	Drl	71	6	6	Hamilton group	3	Hand	50	..	Dom	Driller reports small yield at 54 feet.
Se 242	10M, 6.8N, 6.0W	H. Robson	650	Dug	23	48	5	Hamilton group	5.2	Suction	5	48	Dom	
Se 243	10M, 6.1N, 6.7W	Gus Utzman	600	Drl	217	6	20	Hamilton group	20	Force	5	..	Farm	Water contains hydrogen sulfide.
Se 244	10M, 5.4N, 6.7W	O. Kemp	620	Dug	44	36	44	Pleistocene deposits	15.8	Pitcher	5	50	Dom	
Se 246	10M, 4.0N, 7.5W	Melco Wood Products	590	Drl	35	6	11	Hamilton group	5	Suction	4	..	Dom	
Se 247	10M, 13.9N, 6.9W	Nelson Van Nostrand	610	Drl	19	6	6	Hamilton group	4	Suction	10	..	Farm	
Se 248	10M, 3.5N, 6.6W	R. C. Gambee	670	Drl	225	6	50	Hamilton group	30	Force	20	..	Dom	
Se 250	10M, 8.9N, 5.4W	R. L. Schaffer	510	Drl	76	6	5	Onondaga limestone	25	Force	30	..	Dom	
Se 251	10M, 10.0N, 5.8W	C. H. Pratz	460	Drl	67	6	4	Onondaga limestone	..	Jet	70	..	Farm	
Se 252	10M, 6.9N, 7.4W	E. J. Hines	500	Dug	28	48	28	Pleistocene deposits	16	Force	20	48	Dom	(a)
Se 254	10M, 5.7N, 9.1W	H. L. Opdyke	560	Drl	244	6	10	Hamilton group	100	..	5	50	Farm	Water contains hydrogen sulfide.
Se 255	10M, 3.1N, 9.3W	Louis Olschewski	460	Drl	74	6	50	Hamilton group	15	..	10	..	Dom	Water reported to contain hydrogen sulfide and to have a high iron content.
Se 256	10M, 2.3N, 9.0W	Robert Whitaker	460	Drl	75	6	5	Hamilton group	..	..	5	..	Dom	
Se 257	10M, 3.0N, 7.3W	George Watts	620	Drl	135	6	32	Hamilton group	40	Jet	15	..	Farm	
Se 258	10M, 1.7N, 8.9W	S. A. Russell	460	Drl	100	6	...	Hamilton group	7	Suction	30	..	Dom	Well is reported to have flowed when drilled; water contains hydrogen sulfide.
Se 260	10M, 0.1N, 8.3W	V. G. Crane	550	Drl	48	6	9	Hamilton group	4	Suction	60	44	Farm	
Se 261	10M, 0.6N, 7.6W	E. Petagua	600	Drl	42	6	18	Hamilton group	8	Jet	6	..	Com	
Se 263	10M, 0.1N, 7.8W	G. E. Covert	590	Drl	48	6	18	Hamilton group	18	Force	5	..	Dom	
Se 264	10M, 9.5N, 9.1W	Robert Conway	460	Drl	87	6	...	Pleistocene gravel	9	..	50	48	Dom	Well flows in the spring.[a b]
Se 266	10M, 12.2N, 0.1W	H. B. Travis	390	Dug	12	36	12	Pleistocene gravel	4	Jet	30	..	Farm	Water contains hydrogen sulfide.
Se 267	10M, 12.7N, 0.3W	Carl Shuster	440	Drl	65	6	32	Salina formation	32	Force	9	..	Farm	(a)

See footnotes at end of table.

Table 7.—Records of selected wells in Seneca County, New York (Continued)

Well number	Location	Owner	Altitude above sea level (feet)	Type of well	Depth (feet)	Diameter (inches)	Depth to bedrock (feet)	Geologic subdivision	Water level below land surface (feet)	Method of lift	Yield (gallons per minute)	Temperature (° F.)	Use	Remarks
Se 268	10M, 12.9N, 0.5W	A. E. Burroughs	400	Drl	50	6	30	Salina formation	32	Force	20	..	Farm	
Se 271	10M, 4.0N, 6.6W	Sheffield Farms	610	Drl	75	6	28	Hamilton group	65	..	12	48	Ind	(a)
Se 272	10M, 1.2S, 4.1W	E. Hinman	750	Dug	23	36	...	Pleistocene deposits	8.3	..	6	52	Farm	
Se 273	10M, 1.1S, 3.0W	H. G. Jennings	720	Dug	22	36	...	Pleistocene deposits	3	Force	2	..	Farm	Well reported dry during periods of low precipitation.
Se 274	10M, 0.8S, 1.5W	C. L. Garnett	560	Dug	42	36	...	Pleistocene deposits	4	Jet	5	50	Farm	
Se 275	10M, 1.1S, 1.0W	Robert Croasdale	400	Drl	100	6	30	Hamilton group	20	Jet	3½	..	None	
Se 276	10M, 1.4S, 0.7W	George Lynd	400	Drl	52	6	20	Hamilton group	8	..	3	..	Dom	
Se 278	10M, 2.2S, 2.0W	H. M. Kinne	700	Drl	110	6	6	Hamilton group	12	..	1	..	Farm	Well reported dry during periods of low precipitation.
Se 281	10M, 4.7S, 1.2W	K. Welch	764	Drl	20	6	4	Genesee group	6	Suction	8	..	Farm	Well flows in the spring.
Se 282	10M, 4.8S, 2.8W	A. H. Maleski	900	Drl	127	6	4	Genesee group	40	Force	3	..	Farm	
Se 284	10M, 1.8S, 3.6W	John Bromka	742	Drl	110	6	8	Hamilton group	30	Force	10	..	Dom	
Se 285	10M, 1.8S, 2.5W	Edward Kuleso	710	Drl	120	6	65	Hamilton group	15	Force	6	50	Dom	Water turns red after pumping a short time.[a]
Se 287	10M, 5.6S, 2.0W	R. G. Spencer	920	Drl	100	6	2	Hatch and Cashaqua shales	8	..	4	..	Farm	
Se 288	10M, 5.5S, 1.0W	Edward Jacob	810	Drl	63	6	4	Genesee group	..	..	2	..	Farm	Well can easily be pumped dry.
Se 290	10M, 5.9S, 2.5W	Leon Cooper	980	Drl	32	6	22	Hatch and Cashaqua shales	..	..	2	..	Dom	Well flowed when drilled; water contains small amount of hydrogen sulfide.
Se 293	10M, 6.5S, 0.5W	G. B. Akins	850	Drl	42	6	10	Hatch and Cashaqua shales	20	..	6	..	Farm	
Se 296	10M, 7.6S, 3.9W	J. McCheyne	960	Dug	20	36	...	Pleistocene till	11.7	Hand	3	50	Dom	
Se 297	10M, 7.5S, 2.4W	Bert Boyce and Sons	1,110	Drl	58	6	29	Hatch and Cashaqua shales	..	..	10	..	Farm	
Se 299	10M, 7.4S, 1.3W	H. Carpenter	1,020	Dug	24	36	24	Pleistocene till	4	Suction	6	..	Dom	
Se 301	9M, 0.2N, 9.1W	William Lasher	420	Drl	65	6	...	Pleistocene gravel	25	Force	30	..	Farm	Drawdown reported to be about 1 foot after pumping at the rate of 30 gallons per minute for several hours.
Se 302	10M, 4.3S, 3.6W	V. Kaiser	840	Drl	80	6	3	Genesee group	6	Jet	1	..	Dom	
Se 304	10M, 3.6S, 4.9W	P. Kinne	720	Drl	52	6	30	Hamilton group	15	Force	2	..	None	Well not used; water reported red and cloudy.
Se 305	10M, 3.6S, 4.8W	P. Kinne	730	Drl	48	6	8	Hamilton group	10	Jet	20	..	Farm	
Se 307	10M, 3.8S, 6.0W	P. Rooney	640	Drl	27	6	3	Hamilton group	9	Suction	60	..	Farm	Water reported to be cloudy at times.
Se 308	10M, 4.9S, 4.5W	Starr Shaw	810	Drl	115	6	18	Genesee group	10	..	10	..	Com	(a) (b)
Se 310	10M, 4.6S, 6.2W	Frank Moses	580	Drl	157	6	31	Hamilton group	30	..	30	..	Dom	(b)

See footnotes at end of table

Table 7.—Records of selected wells in Seneca County, New York (Continued)

Well number	Location	Owner	Altitude above sea level (feet)	Type of well	Depth (feet)	Diameter (inches)	Depth to bedrock (feet)	Geologic subdivision	Water level below land surface (feet)	Method of lift	Yield (gallons per minute)	Temperature (° F.)	Use	Remarks
Se 311	10M, 5.7S, 5.4W	F. Parker	730	Drl	93	6	26	Genesee group	20	..	6	..	Dom	
Se 312	10M, 7.0S, 5.3W	E. H. Boyd	770	Dug	21	36	...	Pleistocene till	8.6	Hand	½	56	Dom	
Se 313	10M, 7.9S, 5.4W	Tom Van Fleet	700	Dug	15	36	15	Pleistocene till	7	Suction	3	..	Dom	
Se 314	10M, 8.3S, 4.9W	H. Townsend	870	Dug	30	36	30	Pleistocene till	22	Force	..	..	Dom	
Se 317	10M, 8.6S, 3.8W	Van Vleet Brothers	1,040	Drl	80	6	12	Hatch and Cashaqua shale	12	Force	8	..	Farm	
Se 318	10M, 8.6S, 2.7W	Lewis Hungerford	1,180	Dug	20	72	5	Hatch and Cashaqua shale	18	Force	..	..	Dom	
Se 320	10M, 8.0S, 1.8W	Frank Graber	1,090	Drl	88	6	20	Hatch and Cashaqua shale	7	Jet	15	52.5	Farm	
Se 323	10M, 8.0S, 0.7W	H. H. Horton	1,010	Drl	38	6	12	Hatch and Cashaqua shale	..	..	3	..	Farm	
Se 328	10M, 6.4S, 1.7W	L. Holmes	960	Drl	33	6	15	Hatch and Cashaqua shale	10	..	6	..	Dom	
Se 329	10M, 9.4S, 2.3W	J. F. Voorhees	1,230	Drl	80	6	12	Hatch and Cashaqua shale	10	Jet	5	..	Dom	
Se 331	10M, 9.4S, 3.7W	C. D. Stewart	1,120	Drl	100	6	28	Hatch and Cashaqua shale	30	..	3	..	Dom	
Se 332	10M, 9.6S, 5.3W	J. C. Covert	800	Drl	100	6	20	Hatch and Cashaqua shale	25	Jet	6	..	Dom	
Se 333	10M, 8.8S, 6.3W	H. C. Wyckoff	500	Drl	57	6	38	Genesee group	25	..	20	..	Dom	(a)
Se 336	10M, 3.6S, 6.3W	C. Shaw	620	Drl	40	6	20	Hamilton group	7	Suction	6	..	Dom	
Se 337	10M, 5.4S, 3.8W	Ovid Central School	970	Drl	32	8	32	Pleistocene gravel	14	Force	20	..	Dom	Well finished with 5 feet of screen.
Se 338	10M, 5.3S, 3.8W	Village of Ovid	971	Drl	20	18	...	Pleistocene sand	..	Centrifugal	200	..	PWS	Well finished with 5 feet of screen and gravel-packed between depths of 15 and 20 feet. One other similar well at this site.[a]
Se 339	10M, 7.0S, 6.0W	Allen Palmeroy	490	Drl	82	6	14	Hamilton group	..	..	..	..	Dom	Driller reports water encountered at depths of 40 and 65 feet.
Se 343	10M, 10.5S, 1.8W	T. Young	1,270	Drl	54	6	18	Grimes-Wiscoy sequence	35	Force	6	..	Farm	(a)
Se 345	10M, 9.4S, 1.6W	Albert Marshall	1,200	Drl	146	6	23	Hatch and Cashaqua shale	25	Force	½	52	Dom	
Se 346	10M, 12.3N, 1.8W	C. Cross	460	Drl	111	6	44	Salina formation	18	..	5	..	Dom	(b)
Se 348	10M, 11.4S, 5.3W	Arthur Budin	960	Drl	165	6	10	Hamilton group	10	Suction	8	..	Farm	
Se 350	10M, 12.7S, 5.6W	Warren Rulapough	940	Dug	14	36	14	Pleistocene till	..	..	6	..	Dom	Water flows by gravity to house.
Se 351	10M, 13.9S, 6.1W	T. F. Marsh	820	Drl	61	6	7	Hatch and Cashaqua shale	12	Suction	6	..	Farm	

See footnotes at end of table.

Table 7.—Records of selected wells in Seneca County, New York (Continued)

Well number	Location	Owner	Altitude above sea level (feet)	Type of well	Depth (feet)	Diameter (inches)	Depth to bedrock (feet)	Geologic subdivision	Water level below land surface (feet)	Method of lift	Yield (gallons per minute)	Temperature (° F.)	Use	Remarks
Se 353	10M, 13.6S, 5.8W	L. W. Poth	940	Drl	80	6	20	Hatch and Cashaqua shale	25	Force	6	..	Dom	
Se 356	10M, 10.3S, 0.8W	G. M. Townsend	1,190	Dug	16	36	...	Pleistocene till	12	Pitcher	5	51	Dom	
Se 357	10M, 10.4S, 2.6W	L. K. Hunt	1,280	Drl	60	6	19	Grimes-Wiscoy sequence	20	Force	5	..	Farm	
Se 359	10M, 11.3S, 1.7W	E. H. Covert	1,350	Drl	55	6	18	Grimes-Wiscoy sequence	..	..	4	..	Farm	
Se 360	10M, 11.9S, 1.6W	Edward Ward	1,385	Dug	17	36	...	Pleistocene till	14	Pitcher	3	51	Dom	
Se 362	10M, 13.4S, 1.6W	E. L. James	1,530	Drl	265	6	6	Grimes-Wiscoy sequence	5	Jet	2.5	..	Dom	(a)
Se 364	10M, 13.4S, 1.2W	Harry Mertz	1,440	Drl	82	6	6	Grimes-Wiscoy sequence	5	Suction	5	..	Farm	
Se 366	10M, 12.6S, 0.6W	Roy Van Aken	1,360	Dug	20	..	...	Pleistocene till	11.7	..	6	51	Dom	
Se 368	10M, 11.4S, 2.8W	Robert George	1,280	Dug	16	36	...	Pleistocene till	6.6	Suction	3	51	Dom	
Se 370	10M, 11.4S, 0.6W	Charles Treleaven	1,260	Drl	68	6	20	Grimes-Wiscoy sequence	10	Jet	5	..	Dom	(a)
Se 373	10M, 11.5S, 3.9W	Charles Stauffeneker	1,200	Drl	107	6	16	Hatch and Cashaqua shales	7	Jet	16	..	None	
Se 377	10M, 12.5S, 3.6W	James Covert	1,280	Dug	16	36	16	Pleistocene till	7.8	Pitcher	2	52	Dom	
Se 379	10M, 13.5S, 3.9W	W. A. Smith	1,300	Dug	17	36	...	Pleistocene till	11.5	Pitcher	2	..	Dom	(a)
Se 380	10M, 9.3S, 3.9W	Emery Horton	1,060	Drl	65	6	37	Hatch and Cashaqua shales	6	Jet	20	..	Dom	(a)
Se 382	10M, 6.9S, 2.3W	W. A. Cokefair	500	Drl	665	6	34	Hamilton group	38	..	..	..	Farm	Well not used; driller reported yield of ½ gallon per minute at 70 feet.
Se 385	10M, 8.1S, 2.5E	Kidders King's Daughters, Inc.	580	Drl	35	6	3	Genesee group	..	..	10	..	None	Well not used.
Se 387	10M, 12.1S, 4.3E	Albertman Fruit Farm	760	Drl	84	6	13	Hatch and Cashaqua shales	10	Jet	6	..	Farm	Water contains hydrogen sulfide.
Se 388	10M, 11.9S, 3.4E	Hood Foundry Works	880	Drl	50	6	12	Hatch and Cashaqua shales	5	Suction	30	..	Ind	
Se 393	10M, 11.3S, 2.8E	Edward Stickane, Jr.	890	Drl	30	6	10	Hatch and Cashaqua shales	10	Force	3	..	Dom	
Se 394	10M, 11.3S, 2.1E	Sam Robinson	1,010	Dug	22	36	...	Pleistocene till	15	Force	3	..	Dom	
Se 396	10M, 10.9S, 0.3E	Floyd Tunison	1,220	Dug	15	30	15	Pleistocene till	9.5	Suction	2	52	Dom	
Se 399	10M, 10.3S, 0.2E	Donald Betzler	1,160	Drl	40	6	20	Hatch and Cashaqua shales	20	Force	8	..	Farm	
Se 400	10M, 10.0S, 1.3E	Donald Betzler	990	Drl	43	6	18	Hatch and Cashaqua shales	2	Suction	6	..	Dom	
Se 402	10M, 10.7S, 2.6E	R. F. Leary	880	Drl	90	6	40	Hatch and Cashaqua shales	..	..	3	50	Farm	

See footnotes at end of table

Table 7.—Records of selected wells in Seneca County, New York (Continued)

Well number	Location	Owner	Altitude above sea level (feet)	Type of well	Depth (feet)	Diameter (inches)	Depth to bedrock (feet)	Geologic subdivision	Water level below land surface (feet)	Method of lift	Yield (gallons per minute)	Temperature (° F.)	Use	Remarks
Se 405	10M, 11.4S, 3.9E	Covert Apple Orchard	720	Drl	68	6	13	Hatch and Cashaqua shales	..	..	8	..	Farm	Well supplies water for 35 farm laborers.
Se 407	10M, 6.3S, 1.6E	H. B. Wyckoff	580	Drl	79	6	54	Hamilton group	18	Force	9	..	Farm	
Se 409	10M, 5.9S, 2.4E	L. P. Getman	400	Drl	89	6	16	Hamilton group	12	Jet	1	..	Dom	
Se 415	10M, 6.4S, 0.2E	Frank Delong	790	Dug	13	36	12	Pleistocene till	6.3	Suction	8	58	Farm	
Se 417	10M, 6.1S, 1.1E	Elmore Blew	600	Drl	58	6	18	Hamilton group	10	Suction	8	..	Farm	Water is reported to contain hydrogen sulfide.
Se 419	10M, 9.5S, 2.8E	Glen Metlock	660	Drl	59	6	11	Hatch and Cashaqua shales	2	Suction	3	..	Dom	
Se 421	10M, 9.5S, 3.0E	H. Brinkerhoff	660	Drl	128	6	18	Hatch and Cashaqua shales	17	Jet	6	..	Farm	
Se 422	10M, 5.7S, 0.9E	George Meyer	580	Drl	65	6	8	Hamilton group	4	Suction	3	..	Farm	
Se 424	10M, 12.2S, 4.7E	A. W. Booth	680	Drl	40	6	4	Hatch and Cashaqua shales	10	Jet	2	..	Dom	
Se 427	10M, 13.0S, 5.1E	R. M. King	740	Drl	68	6	16	Hatch and Cashaqua shales	40	Jet	3	..	Dom	
Se 429	10M, 14.0S, 6.1E	J. Mount	750	Drl	39	6	9	Hatch and Cashaqua shales	6	Jet	1	..	Dom	
Se 430	10M, 13.4S, 5.5E	C. H. Georgia	730	Drl	31	6	12	Hatch and Cashaqua shales	8	Suction	1	..	Dom	[a]
Se 432	10M, 9.8S, 2.3E	E. Powell	800	Drl	86	6	17	Hatch and Cashaqua shales	..	Jet	6	..	Farm	
Se 436	10M, 7.1S, 0.4E	Charles Beardsley	820	Drl	37	6	18	Hatch and Cashaqua shales	10	..	6	..	Farm	
Se 440	10M, 8.2S, 1.1E	E. Updike	820	Drl	100	6	20	Hatch and Cashaqua shales	30	Force	2	..	Farm	Water contains small amount of hydrogen sulfide.
Se 444	10M, 8.5S, 2.2E	J. F. Lincoln	620	Drl	31	6	12	Genesee group	6	Suction	13	..	Dom	
Se 446	10M, 8.6S, 1.1E	J. B. Usher	850	Drl	368	6	20	Hatch and Cashaqua shales	10.7	Suction	6	54	None	Well not used; driller reports yield of 6 gallons per minute obtained at 60 feet.
Se 448	10M, 12.2S, 2.1E	L. A. Stillwell	1,120	Drl	130	6	47	Hatch and Cashaqua shales	10	Suction	3	..	Farm	
Se 449	10M, 12.3S, 2.5E	L. A. Stillwell	1,060	Drl	60	6	6	Hatch and Cashaqua shales	..	..	2½	..	Farm	
Se 450	10M, 12.4S, 0.3E	A. Weighous	1,270	Drl	27	6	...	Pleistocene gravel	20	Jet	5	..	Farm	
Se 451	10M, 13.5S, 1.5E	Ralph Judd	1,200	Drl	148	6	29	Hatch and Cashaqua shales	20	Jet	15	..	Farm	
Se 452	10M, 12.9S, 0.4E	M. Mabie	1,300	Drl	90	6	22	Grimes-Wiscoy sequence	30	Force	5	..	Farm	
Se 453	10M, 12.3S, 0.9E	B. Harvey	1,200	Drl	152	6	24	Hatch and Cashaqua shales	4	Suction	½	..	Farm	

See footnotes at end of table.

Table 7.—Records of selected wells in Seneca County, New York (Continued)

Well number	Location	Owner	Altitude above sea level (feet)	Type of well	Depth (feet)	Diameter (inches)	Depth to bedrock (feet)	Geologic subdivision	Water level below land surface (feet)	Method of lift	Yield (gallons per minute)	Temperature (° F.)	Use	Remarks
Se 454	10M, 10.8S, 1.3E	H. Erickson	1,080	Drl	48	6	35	Hatch and Cashaqua shales	12	Force	1	52	Farm	
Se 456	10M, 12.6S, 1.5E	Charles Hausner	1,140	Dug	13	36	...	Pleistocene gravel	10.5	Hand	3	..	Dom	
Se 459	10M, 14.0S, 1.5E	C. D. Brokaw	1,260	Dug	35	36	...	Pleistocene gravel	24.7	Force	..	51	Dom	
Se 465	10M, 13.1S, 3.5E	C. W. Bates	1,030	Dug	10	48	...	Pleistocene gravel	6	Suction	..	55	Farm	(a)
Se 469	10M, 14.1S, 3.4E	D. V. Ditmars	1,060	Dug	20	36	20	Pleistocene till	15	Pitcher	2	..	Dom	
Se 471	10M, 5.1S, 1.0E	Herman Horford	520	Dug	20	36	...	Pleistocene till	15	Hand	2	54	Dom	
Se 476	10M, 9.2N, 9.5W	Walter Regal	460	Drl	113	6	110	Onondaga limestone	9	Jet	30	..	Dom	(b)
Se 478	10M, 3.5S, 1.0W	F. C. Ditmars	640	Dug	13	36	13	Pleistocene till	6.2	Hand	3	54	Dom	
Se 480	10M, 3.0S, 0.0E	W. B. Ford	440	Drl	65	6	...	Pleistocene sand and gravel	50	..	5	..	Dom	Well reported to have been originally drilled to a depth of 72 feet.[a]
Se 481	10M, 3.0S, 0.1E	W. B. Ford	400	Drv	12	1½	...	Pleistocene sand and gravel	9.5	Jet	4	..	Dom	
Se 482	10M, 3.7S, 0.4E	C. Ditmars	400	Drv	12	1¼	...	Pleistocene sand and gravel	8	Jet	4	..	Dom	
Se 485	10M, 5.5S, 2.9W	E. Bicartis	1,000	Drl	208	6	10	Hatch and Cashaqua shales	..	..	¼	..	Dom	
Se 488	10M, 3.3N, 0.8W	Frank McNish	400	Dug	18	36	...	Pleistocene till	..	Suction	3	..	Dom	Water contains hydrogen sulfide.
Se 490	10M, 4.7N, 0.1W	H. Garnsey	440	Drl	129	6	105	Hamilton group	70	Jet	1	..	Dom	
Se 491	9M, 12.0S, 0.2E	John Nugent	480	Dug	23	36	...	Pleistocene outwash	10.9	Pitcher	3	54	Dom	
Se 498	10M, 9.0N, 10.6W	Harold Nerber	460	Drl	135	6	...	Pleistocene gravel	10	Jet	50	..	Com	(b)
Se 499	10M, 8.4S, 0.2E	E. Wilson	960	Drl	44	6	15	Hatch and Cashaqua shales	29.5	..	2	50	Farm	Water reported to contain small amount of hydrogen sulfide.[a]
Se 500	10M, 10.7N, 4.2W	Nothnagel and Pratz	440	Drl	56	6	40	Manlius and Rondout limestones and Cobleskill dolomite	20	..	4	..	Dom	(b)
Se 501	10M, 14.5N, 5.5W	Lee Lane	500	Drl	25	6	20	Salina formation	13	Jet	30	..	Dom	
Se 503	10M, 11.0N, 3.7W	J. Souhan and Son	440	Drl	50	6	45	Manlius and Rondout limestones and Cobleskill dolomite	20	Jet	15	..	Ind	Owner reports average daily consumption is 20,000 gallons. Water contains small amounts of iron and hydrogen sulfide.[a]
Se 504	10M, 9.1S, 1.6E	Sheffield Farms	856	Drl	260	8	20	Hamilton group	..	Force	50	..	Ind	Owner reports average daily consumption is 10,800 gallons.
Se 509	9M, 0.1N, 6.8W	Grace Serven	500	Drl	40	6	25	Salina formation	15	..	25	..	Dom	
Se 511	10M, 11.1N, 5.3W	G. L. F. Farm Products Coop., Inc.	465	Drl	82	6	56	Onondaga limestone	23	..	75	50	Ind	Well capped and used as a stand-by; yielded 75 gallons per minute for 7.5 hours.[b]

See footnotes at end of table.

Table 7.—Records of selected wells in Seneca County, New York (Concluded)

Well number	Location	Owner	Altitude ove sea level (feet)	Type of well	Depth (feet)	Diameter (inches)	Depth to bedrock (feet)	Geologic subdivision	Water level below land surface (feet)	Method of lift	Yield (gallons per minute)	Temperature (° F.)	Use	Remarks
Se 512	10M, 11.1N, 5.4W	G. L. F. Farm Products Coop., Inc.	460	Drl	75	8	55	Onondaga limestone	30	Turbine	200	51	Ind	Average daily consumption is 288,000 gallons.[a]
Se 513	9M, 0.0N, 0.7W	Louis Prosser	400	Dug	23	18	...	Pleistocene gravel	11	Suction	3	48	Farm	([b])
Se 515	10M, 2.9S, 1.9W	S. Swinehart	710	Drl	179	6	30	Hamilton group	30	Jet	15	..	Dom	([b])
Se 517	9M, 1.0N, 8.2W	Frank Chadwick	440	Dug	14	36	...	Pleistocene till	4	Pitcher	1	53	Dom	Well reported dry during periods of low precipitation.
Se 518	10M, 1.0N, 2.1W	Warne Bros.	620	Drl	50	6	20	Hamilton group	..	..	10	..	Farm	
Se 520	10M, 3.9S, 2.0W	Alex Bean	800	Drl	134	6	8	Hamilton group	15	Jet	6	..	Dom	Well has been pumped continuously at rate of 6 gallons per minute for 48 hours.
Se 521	10M, 8.0S, 2.5W	Bert Boyce	1,140	Drl	229	6	96	Hatch and Cashaqua shales	30	..	1½	..	None	Well not used.
Se 522	10M, 7.4S, 0.5W	R. H. Thompson	920	Drl	44	6	10	Hatch and Cashaqua shales	..	..	5	..	Farm	
Se 523	10M, 10.5S, 3.2E	C. Hayward	720	Drl	119	6	12	Hatch and Cashaqua shales	12	..	50	..	Dom	Water is reported to contain hydrogen sulfide.

[a] For chemical analysis see table 5.
[b] For log of well see table 6.

Table 8.—Reports dealing with ground-water conditions in New York prepared by the U. S. Geological Survey and the New York State Water Power and Control Commission in cooperation with various counties and municipalities and published by the Commission[a]

Bulletin GW	Title	Author(s)	Year published
1	Withdrawal of ground water on Long Island, N. Y.	Thompson, D. G. and Leggette, R. M.	1936
2	Engineering report on the water supplies of Long Island.	Suter, Russell	1937
3	Record of wells in Kings County, N. Y.	Leggette, R. M. and others	1937
4	Record of wells in Suffolk County, N. Y.	Leggette, R. M. and others	1938
5	Record of wells in Nassau County, N. Y.	Leggette, R. M. and others	1938
6	Record of wells in Queens County, N. Y.	Leggette, R. M. and others	1938
7	Report on the geology and hydrology of Kings and Queens Counties, Long Island.	Sanford, Homer	1938
8	Record of wells in Kings County, N. Y.	Leggette, R. M. and Brashears, M. L., Jr.	1944
9	Record of wells in Suffolk County, N. Y., supplement I.	Roberts, C. M. and Brashears, M. L., Jr.	1945
10	Record of wells in Nassau County, N. Y., supplement I.	Roberts, C. M. and Brashears, M. L., Jr.	1946
11	Record of wells in Queens County, N. Y., supplement I.	Roberts, C. M. and Jester, Marion C.	1947
12	The water table in the western and central parts of Long Island, N. Y.	Jacob, C. E.	1945
13	The configuration of the rock floor in western Long Island, N. Y.	De Laguna, Wallace and Brashears, M. L., Jr.	1948
14	Correlation of ground-water levels and precipitation on Long Island, N. Y.	Jacob, C. E.	1945
15	Progress report on ground-water resources of the southwestern part of Broome County, N. Y.	Brown, R. H. and Ferris, J. G.	1946
16	Progress report on ground-water conditions in the Cortland quadrangle, N. Y.	Asselstine, E. S.	1946
17	Geologic correlation of logs of wells in Kings County, N. Y.	De Laguna, Wallace	1948
18	Mapping of geologic formations and aquifers of Long Island, N. Y.	Suter, Russell; De Laguna, Wallace; and Perlmutter, N. M.	1950
19	Geologic atlas of Long Island.	......	1950
20	The ground-water resources of Albany County, N. Y.	Arnow, Theodore	1949
21	The ground-water resources of Rensselaer County, N. Y.	Cushman, R. V.	1950
22	The ground-water resources of Schoharie County, N. Y.	Berdan, Jean M.	1950
23	The ground-water resources of Montgomery County, N. Y.	Jeffords, R. M.	1950
24	The ground-water resources of Fulton County, N. Y.	Arnow, Theodore	1950
25	The ground-water resources of Columbia County, N. Y.	Arnow, Theodore	1951

[a] Records of periodic measurement of the position of the water level in observation wells in New York are printed annually in the water-supply papers of the U. S. Geological Survey. See Water-Supply Papers 777, 817, 840, 845, 886, 906, 936, 944, 986, 1016, 1023, and 1071.

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